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CONTRACT NO: DAMD17-88-C-8141

TITLE: BLAST OVERPRESSURE STUDIES WITH ANIMALS AND MAN

SUBTITLE: Non-Auditory Damage Risk Assessment for Simulated Weapons Fired from an Enclosure

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Frederick, Maryland 21702-5012

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Anesthetized sheep were exposed to a reverberant wave environment like that produced from firing an anti-tank weapon from a room. The simulation was accomplished by detonating C4 explosive outside a chamber of 18.2m^3 volume. The blast wave traveled into the chamber through a 20 cm I.D. tube and was reflected off the back wall and subsequently throughout the chamber. The resulting waveform very closely approximated that generated by a Carl-Gustav anti-tank weapon fired from a chamber. A series of 1 shot; 3 shot, 2.5-min. apart; or 12 shot, 2.5 min. apart exposures were used. The results indicate that multiple shots have a strong additive effect, decreasing the subthreshold levels. The subthreshold for a single blast is estimated to be below a smoothed peak of 31 kPa (approximately 65 kPa unsmoothed). The subthreshold for 3 exposures is estimated to be below 21.5 kPa (approximately 46 kPa unsmoothed). The subthreshold for 12 exposures was not found.

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In conducting this research, the investigator(s) adhered to the "Guide for the Care and Use of Laboratory Animals," prepared by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Animal Resources, National Research Council (NIH Publication No. 86-23, Revised 1985.

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_____ In conducting research utilizing recombinant DNA technology, the investigator(s) adhered to current guidelines promulgated by the National Institutes of Health.

John T. Johnston 11/12/93
PI Signature Date

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TASK ORDER 4

DAMD-17-88-C-8141

BLAST OVERPRESSURE STUDIES WITH ANIMALS AND MAN

SUBTITLE: NON-AUDITORY DAMAGE RISK ASSESSMENT FOR SIMULATED WEAPONS FIRED FROM AN ENCLOSURE

INTRODUCTION

This report describes the results of studies undertaken to establish the non-auditory subthreshold for injury in a reverberant wave environment like that produced from firing an anti-tank weapon from a room. Anesthetized sheep were used throughout the study to determine the extent of the effects from various intensities and repetitions of the simulated weapon blast. The studies were conducted by EG&G Special Projects at the Blast Overpressure Test Site, Kirtland AFB, NM.

BACKGROUND

Previous studies done under this contract have demonstrated that the complex blast waves generated by detonating various weights of bare, spherical C-4 charges in three different enclosure volumes produced varying degrees of nonauditory injury.[1-3] The extent of the injury depended upon the size of the charge detonated

and the location of the animal with respect to the charge and position in the chamber. Injury levels increased with increasing charge weight as in the freefield. However, they also varied as a function of the location of the subject in the enclosure and not necessarily as a function of range from the explosion as in the freefield. Animals in the corners sustained more severe injuries in the form of solid intra-abdominal organ damage than those located away from the multiple reflecting surfaces and at shorter distances from the explosion. This was particularly true at the higher blast levels. At the higher levels, the reflected waves tended to focus, producing "incident reflected waves" 3 to 10 times higher than those generated in the freefield at the same ranges and explosive weights.

It was also demonstrated that quasi-static pressure did not influence lung, upper respiratory tract, or GI tract injury to any appreciable degree. Nonetheless, the reverberant nature of the complex wave was altered by changing the quasi-static pressure which did appear to have a slight effect on solid intra-abdominal organ response. There was a higher incidence of solid intra-abdominal organ injury as well as more severe solid intra-abdominal injury in the subjects exposed in the chamber with the door locked and vent doors closed.

An injury prediction curve using a severity of injury index (SI) and smoothed peak pressure (Psm) as correlates appeared to be an adequate model for the information that was collected. The severity index data predicted a no-injury window for a Psm

extending from 0 to 57 kPa. The 57 kPa was adjusted upward from the 49 kPa zero crossing of the curve to compensate for the control injury level of 0.05. Trace to slight injuries were estimated for pressures extending from 57.1 to 130 kPa. For values ranging from 130.1 to 221 kPa, slight to extensive injuries were predicted. Moderate to lethal levels of injury were expected over a span of 221 to 428 kPa. At pressures above 428.1 kPa, lethality was predicted to exceed 50 percent. It was also found that, intra-abdominal injury notwithstanding, by converting Psm to maximum peak pressure (Pmax), there was a good correlation between the injury prediction curve and the "Bowen freestream survival curves"[4] for 2 to 3 ms duration waves.

This implies that the pulse with highest peak and longest duration of the individual pressure pulses in the complex wave is primarily responsible for injury production, with limited additive effects from the multiple shocks associated with the reverberant wave. The extent to which this relationship holds true for other classes of waveforms needs to be clarified. This report deals with the generation of another class of waveforms in which bare charges of C-4 were detonated and introduced into a test chamber via a modified shock tube.

OBJECTIVES

There were three basic objectives of this study which included two protocol amendments.

1. To provide data for the validation of the Jaycor injury prediction model by the Walter Reed Army Institute of Research (WRAIR).
2. To determine the non-auditory subthreshold level from 1, 3, and 12 exposures to a complex wave environment similar to that produced from firing an anti-tank weapon from an enclosure.
3. To correlate the results with those from other studies to to establish additional damage risk criteria for complex wave environments if necessary.

METHODS

The instrumentation cylinder was used to map the pressure-time environment at various locations in the weapon blast simulator (illustrated in Figure 1) to develop a waveform similar to that generated by the Carl-Gustav anti-tank weapon. Once the location in the chamber (illustrated in Figure 2) for the best waveform simulation was established, anesthetized sheep were exposed to various intensities and repetitions of the simulated wave. With but one exception , the same basic approach was used throughout the study. As illustrated in Figure 3, two anesthetized sheep at a time were fitted with cotton webbing or fish net harnesses and suspended from the ceiling of the enclosure at a height of 1.2 m

from the floor as measured to the xiphisternum for exposure. One sheep was placed in the location the instrument cylinder was in during waveform and calibration curve development and the other sheep was placed on the opposite side of the gun barrel in a mirror image location facing the other sheep. The one exception was one test with one sheep only.

Waveform Development

The pressure-time environment was recorded at various locations in the chamber as illustrated in Figures 1 and 2 to establish the exposure positions for the test subjects and to provide input parameters to the WRAIR to model the pressure-time environment throughout the room. Most of the measurements were taken around the barrel of the simulator at a height of 1.2 m off the floor using the free air gauges and the instrumentation cylinder that was used in the Task Order 2 experiments. The pressure-time patterns that were selected by Walter Reed Army Institute of Research (WRAIR) and the U.S. Army Aeromedical Research Laboratory (USAARL) to simulate the Carl-Gustav anti-tank weapon blastwave were recorded by the instrumentation cylinder located in the position shown in Figure 2. Pressure-time recordings from 454-, 907 , 1361- and 1814-g C-4 charge detonations were used to develop the initial calibration curves for the smoothed peak pressure (Psm) and the maximum peak pressure (Pmax). The Psm versus charge weight calibration curve is illustrated in Figure 4.

For this study the average blast load on the instrumentation cylinder for the position illustrated in the figure was considered to be the blast dose to the animals exposed in the same equivalent locations. The average pressure-time values were calculated from gauges 1 through 4 of the instrumentation cylinder for each charge weight for correlation with the severity of injury indices of each exposure group.

A break was taken during the single exposure tests to take additional calibration shots at the calculated experimental blast levels that were being used in the study to arrive at the final calibration curves for Psm and Pmax.

Experimental Design

The design for the study is presented Table 1. Varying numbers of anesthetized sheep were subjected to 1, 3 or 12 blasts of simulated anti-tank waveforms in 1.5- to 3-dB increments. The exposure doses and charge weights were derived from the 454-, 907-, 1361-, and 1814-g C-4 charge calibration shots mentioned above. There were three experiments based upon the number of exposures the animals received. Pairs of controls were used at intervals throughout the study to compensate for any lesions induced by iatrogenic factors or disease. All animals were treated the same and mounted in position for 28 minutes whether they were exposed or not. This allowed the controls to be compared interchangeably between groups. There were 110 sheep in the single exposure tests, 82 in the 3 exposure tests, and 29 in the 12 exposure tests. The

interval between shots was approximately 2.5 minutes. The experiments will be described in the order in which they were done.

Twelve Exposure Experiments

There were five groups of four each, with the exception of the first group in which there was one additional animal and eight controls as seen in Table 1. Five different pressure levels were used, starting at a Psm of 84.6 kPa and going down in 3-dB steps to 21.1 kPa to establish the approximate severity of injury and injury thresholds for the various organs. At 21.1 kPa, further exposures were stopped because threshold had not been reached. Emphasis then shifted in doing the three exposure experiments.

Single Exposure Experiments

For the single exposure experiments, there were 96 animals in six groups with varying numbers of animals per group depending upon the pressure level and 14 controls which are listed in Table 1. Initially, two animals each, were exposed in 3-dB increments to smoothed peak pressures of 84.6, 59.8, 42.2, 29.9 and 21.1 kPa to estimate the threshold and subthreshold levels based on severity of injury scores. The various groups were filled in with additional animals to establish statistically significant threshold and subthreshold levels for injury. One 1.5-dB step down from 59.8 to 50.3 kPa was done in addition to the 3-dB steps to estimate the threshold for injury level.

Three Exposure Experiments

The protocol was amended to establish the subthreshold for injury level for three exposures to the simulated anti-tank weapon blast. It was felt that the three exposure scenario better reflected the actual use of the weapon during training. Groups of 20, 10 and 40 subjects each were exposed to respective Psm levels of 25.6, 21.1, and 17.7 kPa. A total of 12 controls were used during this test series.

Test Enclosure

As seen in Figure 1, the all-steel-enclosure that was built for Task Order 2 was converted to a "simulator" to satisfy Task Order 4 requirements. The partition wall was adjusted to the 18.2 m^3 volume used in the FY 90 tests. A hole was cut in the wall directly opposite the door to allow the introduction of a 249-cm long 'gun barrel' constructed from a piece of seamless high-pressure steel tube. It had an inside diameter of 20 cm and a 2.54-cm thick wall. This tube extended 152 cm into the chamber. The tube was horizontally mounted with its centerline 122 cm from the floor and supported inside the chamber by a 2.54-cm thick stand that consisted of a 46- x 33-cm base plate, a vertical member that decreased in width from 30 to 19 cm, and a barrel mount. The mount was comprised of a 30- x 16- x 2.54-cm support plate and a 15-cm wide by 1.27-cm thick band that surrounded the tube. External support for the barrel was furnished by the barrier wall which was constructed from a 244- x 244-cm sheet of 2.54-cm thick steel and

a 10-49 I-beam (10-inch wide flange I-beam weighing 49 lb/ft^3). The barrel extended 3 cm beyond the barrier wall and was surrounded by a 'receiver' constructed from a 30-cm length of 2.54-cm-thick wall high pressure tubing. The receiver tapered from 42- to 41-cm ID. It was surrounded by two radial and eight longitudinal gussets fabricated from a 2.54-cm plate to increase its hoop strength. A movable 152- x 122-cm 'driver' section fabricated from two 15-cm thick plates of salvaged battleship armor was installed 15 cm downstream from the leading edge of the receiver. There was a 20-cm diameter hole cut in the slab of armor adjacent to the receiver and was inline with the centerline of the gun barrel.

The simulator was operated by detonating a spherical charge of C-4 explosive in the mouth of the opening in the driver section to approximate the backblast from a weapon firing. The blast wave traveled down the barrel into the enclosure and was reflected off of the backwall. The wave shape varied as a function of location in the room. The wave intensity was changed by changing the charge weight. The simulator was operated with the enclosure inertia vent doors open to minimize quasi-static pressure rise and to eliminate explosive decomposition products.

Instrumentation

Piezotronics (PCB) Model 102M152 or Model 102M165 piezoelectric pressure transducers as well as the instrumentation cylinder, provided by the Walter Reed Army Institute of Research (WRAIR) were used during the study. The instrumentation cylinder

was fitted with four ablative coated PCB Model 102M125 gauges at 90-degree intervals around its circumference and at the midpoint of its long axis. The 102M152's and 102M165's were used as side-on free air gauges mounted vertically with their sensing elements pointing face-up or mounted face-on in three of the enclosure walls. A 102M165 with ablative coating was located at the end of the barrel during the animal experiments. A 1- to 2-mm-thick layer of temperature resistant, high-vacuum grease impregnated with charcoal was coated on the sensing element of each of the free air gauges before each shot to mitigate any possible thermal or flash effects. Signals from the transducers were passed out of PCB inline voltage mode followers into power conditioners through Tektronix Model AM502 differential amplifiers unfiltered. Unfiltered signals were simultaneously recorded on an Ampex Model PR2230 dc to 80 kHz FM tape recorder and digitized over 13 of 15 segments of 8k data points each at a 4 μsec sample interval with a Pacific Instruments data acquisition system operating in conjunction with a Compaq Desk Pro Model 386/20e personal computer. The first 2 of the 15 segments were used to establish the baseline for the data array. The analog tape was kept for archival purposes. The digitized data was stored on 20 and 44 Mbyte Bernoulli disk cartridges for analysis using the blast data acquisition and analysis software developed for EG&G by Professional Computer Consultants. The data stored on the 44 Mbyte disks were also sent to the WRAIR for further analysis.

Animal Care

A total of 221 female Columbia-Rambouillet cross sheep having body weights of approximately 41 to 50 kg were used during the study. They were treated for endoparasites and their ears were sprayed with tick pesticide four days after arrival at the laboratory outdoor pens. The drinking water was also treated with terramycin powder at a rate of 0.6 g/liter for 2 weeks to help reduce the incidence of pulmonary complications.

The animals were maintained in one of four outdoor pens. Each per which had a portion with an overhead cover. One to two weeks prior to testing, the subjects were sheared in groups of 6 to 10. given a second application of tick spray, and moved to an indoor holding facility. They were kept in groups of 4 to 6 in pens with wood shavings on the floor. Food pellets were provided at a rate of 1 kg/head/day. Water was available ad libitum. Each test animal was fasted a minimum of 18 hours before a test.

On the morning of a test, the animals were harnessed, weighed and given a otoscopic examination to remove any obstruction from the ear canals prior to transport to the test site. The ear or ears that were to be protected were blocked with a selected earplug. Each sheep received a preanesthetic intramuscular (IM) injection of atropine sulfate (0.44 mg/kg) and xylazine (0.22 mg/kg) and was placed in its test position approximately 15 minutes prior to blast exposure. At 5 minutes before the test, each sheep was anesthetized with an IM injection of ketamine hydrochloride (11 mg/kg) then exposed to blast.[5,6]

Pathology Scoring

The subjects were not allowed to recover from anesthesia. Starting at approximately one hour after blast exposure, one sheep at a time was given an IM injection of ketamine hydrochloride (22 mg/kg), exsanguinated by severing the jugular veins and carotid arteries, and necropsied. Each animal was assessed for injuries using the alphanumeric scoring system described in the Task Order 2 final report.[3] Trauma to the pharynx/larynx, trachea, lungs, heart, hollow abdominal organs, and solid abdominal organs were assigned individual numerical scores based on the severity of the lesion. The various lesions were also graded trace, slight, moderate, or extensive depending upon their severity.

The alphanumeric pathology scoring system for the most commonly injured nonauditory organs is listed as follows:

Pathology Scoring System

Severity	Lung	Phx/Lyx	Trachea	GI Tract	Intra-abdominal
Negative	0	0	0	0	0
Trace	1-4	1-4	1-4	1-4	1-4
Slight	5-21	5-16	5-18	5-18	5-18
Moderate	22-36	17-22	19-28	19-28	19-28
Extensive	37+	23+	29+	29+	29+
Maximum Possible	64	60	55	48	44

The ears were evaluated based upon the percentage of eardrum ruptured. An additional numerical score was given for each ear for the amount of eardrum damaged and ossicular chain involvement.

Each individual injury score was divided by its preassigned maximum possible score to arrive at a severity of injury ratio for that organ or system. The maximum possible score varied as a function of the number of components the organs were divided into and the possible levels of severity assigned to them. The presence or absence and the extent of a pneumothorax, hemothorax, hemoperitoneum, coronary air or cerebral air were summed and added to the sum of the ratios. The resulting value was the adjusted severity of injury index which was arrived at by excluding the ear damage values from the sum of the ratios.

Data Analysis

The 1, 3, and 12 exposure sheep pathology results were evaluated in terms of the number and the intensity of the reverberant wave. Injury levels in terms of damage to specific organs and adjusted severity of injury indices were listed in descending order of charge weight. The Pmax and Psm pressures, calculated from the instrumentation cylinder calibration curves, were correlated with the corresponding severity of injury indices to determine the nonauditory subthreshold and threshold for injury levels in relation to the number of exposures to the simulated anti-tank weapon blast wave. Pressure-time output from wall gauge number 10, which was located at neck level between the two test animals, was listed for every shot on the single- and three-exposure experiments and for the first, sixth, and twelfth shot on the 12 exposure experiment to estimate the reproducibility of the

blast environment and to compare to the instrumentation cylinder correlations. The single exposure results were also compared to the no-injury data from the Task Order 2 report.

RESULTS

The results of the waveform modeling efforts and final calibration curve development will be presented first, followed by the experimental pathology assessment results for the study.

The pressure-time data recorded at the various gauge locations during calibration and waveform development are listed in terms of Pmax and Psm in Tables A-1 and A-2 of Appendix A. The average values for various instrumentation cylinder gauge combinations were also calculated.

The pathology assessments, for the major organs including eardrum injury and severity of injury indices, are given in Table B-1 of Appendix B. They were listed in terms of numbers of exposures and in descending order of charge weight.

The wall gauge pressure-time data taken to monitor the shot-to-shot blast environment reproducibility for each animal test are tabulated in Table C-1 of Appendix C. Along with the mean, the standard deviation and standard estimate for each pressure level are also given.

Waveform Development

As previously mentioned, the waveforms that were considered to be the best simulants of the Carl-Gustav anti-tank weapon blast

wave were recorded by the instrumentation cylinder in the location depicted in Figure 2. Initial calibration shot pressure-time records from gauge one for 454-,907-, 1361- and 1814-g charge detonations are illustrated in Figures 5 through 8. A blast wave that was recorded at the operator's position during a weapon firing is presented in Figure 9.

The additional calibration shots taken to develop curves relating Pmax and Psm to charge weight are illustrated in Figures 10 and 11. Second order polynomials were used to fit lines to the data points. The points for the curves were the mean values for gauges 1 through 4 listed in Tables A-1 and A-2. Estimates from these curves were used to relate blast overpressure to injury level.

Wall gauge pressure-time measurements listed in Appendix C were also used to evaluate injury level with respect to blast for comparison with the instrumentation cylinder derived Psm calculations.

Non-Auditory Injury Levels

Mean severity of injury index (SI) values from the pathology assessments (listed in Appendix B) versus the Pmax and Psm blast levels (derived from Figures 10 and 11) are presented in Table 2. The severity indices were grouped in terms of number of exposures and descending order of blast intensity. For the convenience of discussion the results are presented in terms of Psm, but can easily be converted to Pmax pressures using the equation in Figure 12 that illustrates the relationship between Pmax and Psm.

For the 12 exposure group, the SI ranged from 2.18 for a Psm of 89.7 kPa to 0.22 for a Psm of 22.8 kPa. A dose-response curve for the group was created using a second order polynomial fit of the data relating SI means to Psm and is illustrated in Figure 13. The number of animals per point were included. The control level SI crossing point occurs at approximately 21.8. However, this approach ignores the strong effect at the low peak values (the SI is still at 0.22) and is clearly not a proper approach for obtaining the non-auditory limit. In fact, we can not really be sure where the limit is for 12 shots. Since it was determined that the 12-shot threshold series was not likely to be a datum point of use to the Army, the effort to find the 12-shot threshold was dropped in favor of the 3-shot series.

Single exposure SI measurements ranged from 0.29 for a Psm of 89.7 kPa to 0.01 for a Psm of 22.8 kPa. The single-exposure curve with the number of animals per point is shown in Figure 14. The control level crossing point occurred at 31.0 kPa.

The SI for the three-exposure group animals ranged from 0.10 at a Psm of 26.9 kPa to 0.01 at a Psm of 19.7 kPa. Figure 15 illustrates the response curve and the number of animals per point. For this group the control level crossing point was approximately 21.5 kPa.

Individual severity of injury scores listed in the Appendix B were also plotted against the instrumentation cylinder Psm levels and are presented in Figures D-1 through D-3 of Appendix D.

The mean severity of injury indices with respect to the wall

gauge 10 Psm means are presented in Table 3. The SI and Psm values generated by 533-g charge detonations and below were equivalent to the SI versus instrumentation cylinder Psm pressures for the same range of charge weights which were listed in Table 2.

DISCUSSION

Waveform Development

Taking into account the differences in scaling, the simulator reverberant blast waves illustrated in Figures 5 through 8 compare quite favorably to the Figure 9 pressure-time pattern recorded at the operator's position during a Carl Gustav anti-tank weapon firing. More importantly, the wave shapes remained reasonably constant as blast intensity increased.

With the exception of the 12-exposure 1361-g tests, the gauge 10 pressure-time data presented in Appendix C, demonstrates that there was good day-to-day blast overpressure level reproducibility, particularly in terms of Psm. The standard deviation for a given Psm mean was typically less than 10 percent of the mean.

Non-Auditory Injury Levels

The single-shot injury prediction curve developed during Task Order 2 is illustrated in Figure 16. This curve predicts trace to slight levels of injuries with SI values ranging from 0.05 to 0.66 for a Psm value range of 57.1 to 130 kPa. For a single exposure, the predicted SI from a Psm of 89.7 kPa would be 0.28.

As indicated in Tables B-1 and Table 2 and illustrated in Figure 13, the average SI of the Carl-Gustav simulation from 12

exposures to a Psm of 89.7 kPa was 2.18. When compared to a single-blast exposure, these results appear to indicate that once threshold levels of injury are reached, additional exposures have almost an additive effect, increasing the severity of injury with each additional blast. The most heavily injured animal at the 89.7 kPa level had an SI of 4.28 which included a ruptured liver and an extensive hemoperitoneum with more than 200 cc of free blood in the abdomen. Trace to slight borderline single exposure of 130 kPa injury prediction of 0.66 was not reached until the blast dose was lowered to 42.8 kPa. The SI versus Psm dose-response curve (Figure 13) illustrates that there were not enough data points in the right places nor number of animals per point to estimate a subthreshold.

The single-exposure group SI data for the animals exposed to 89.7 kPa, listed in Table 2 and illustrated in Figure 14, compare favorably to the Task Order 2 single-shot injury prediction curve in Figure 16. The equation for this curve predicts an SI of 0.28 for a single blast Psm of 89.7 as compared to the mean SI of 0.29 with a range of 0.27 to 0.30 for the two animals actually exposed to this pressure. However, subthreshold predictions are not as close. Assuming a control level SI of 0.03, the single-exposure subthreshold prediction curve shown in Figure 14 estimates subthreshold levels to be below 31.0 kPa. The single shot injury prediction curve of Task Order 2 is not as conservative and predicts subthreshold levels below 57.0 kPa (based on a control SI of 0.05). Thus, the longer reverberation times of the Carl-Gustav

simulation must have an influence on the threshold and subthreshold levels.

The three-exposure group data listed in Table 2 also demonstrate the additive effects of multiple blasts. As illustrated in Figures 14 and 15, the subthreshold limit of 31 kPa for a single shot decreases to 21.5 kPa for 3 exposures. Because of the fewer points used to obtain a subthreshold, a more conservative approach is to use 19.7 kPa as the non-injury point. This point is clearly below the control SI of 0.03.

The wall gauge number 10 mean Psm pressures are a good approximation of the instrumentation cylinder means. The SI versus Psm comparisons for the wall gauge, show that for a Psm below 58.2 kPa the SI versus Psm comparisons are equivalent to SI versus instrumentation cylinder comparisons.

CONCLUSIONS

The waveform developed in the EG&G Blast Simulator for this study is a good approximation of the pressure-time pattern recorded at the operator's position during a Carl-Gustav anti-tank weapon firing. It was demonstrated that the pattern of the reverberant wave was retained as blast intensity increased and that the peak pressure levels were reproducible from day-to-day.

Multiple blasts have an additive effect in increasing the severity of injury as some function of the number of exposures thereby lowering the non-auditory subthreshold levels.

The subthreshold for a single blast exposure is below a Psm 31.0 kPa; whereas it is predicted to be below 19.7 kPa for 3 exposures. A subthreshold for 12 exposures was not found.

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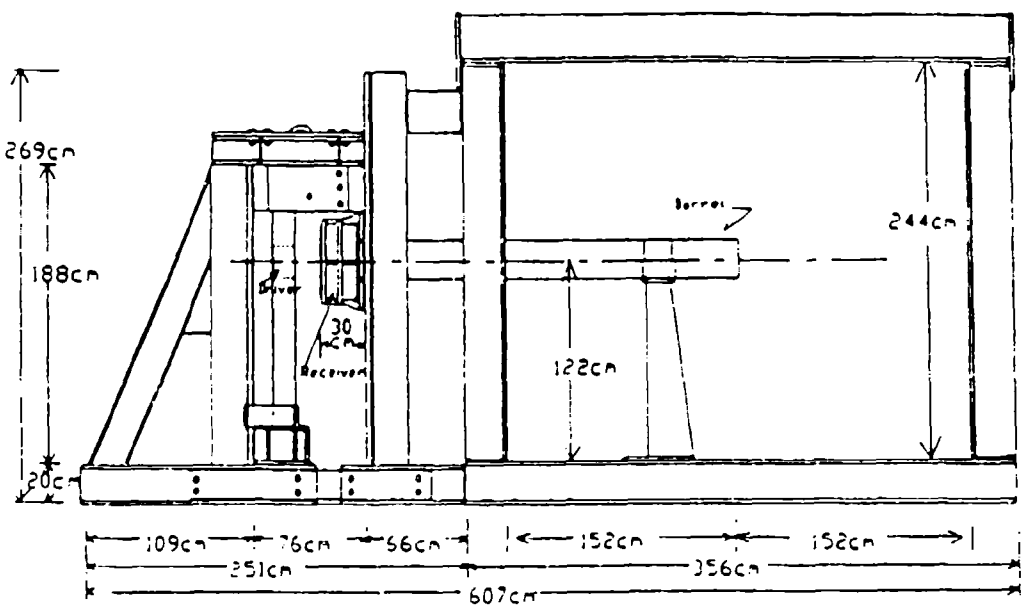


Figure 1. Side view of the 3.05 x 2.44 x 2.44- m configuration of the EG&G Test Enclosure redesigned as a Carl-Gustav anti-tank weapon blast simulator.

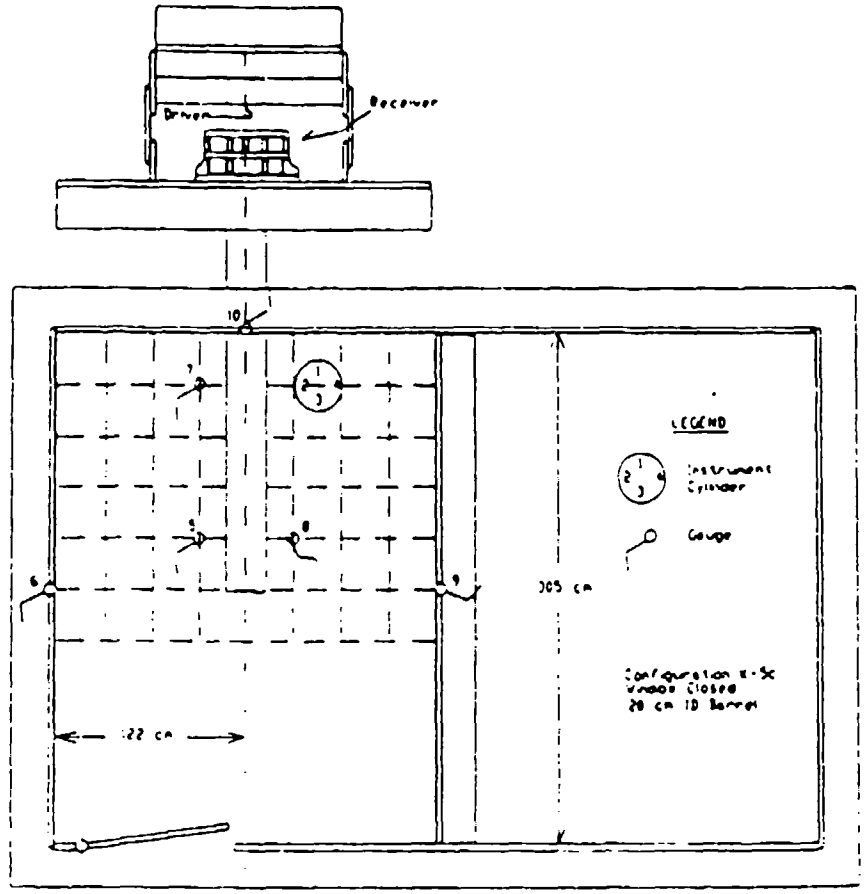


Figure 2. Gauge layout for the Carl-Gustav simulation calibration shots in the 3.05 x 2.44 x 2.44- m enclosure.

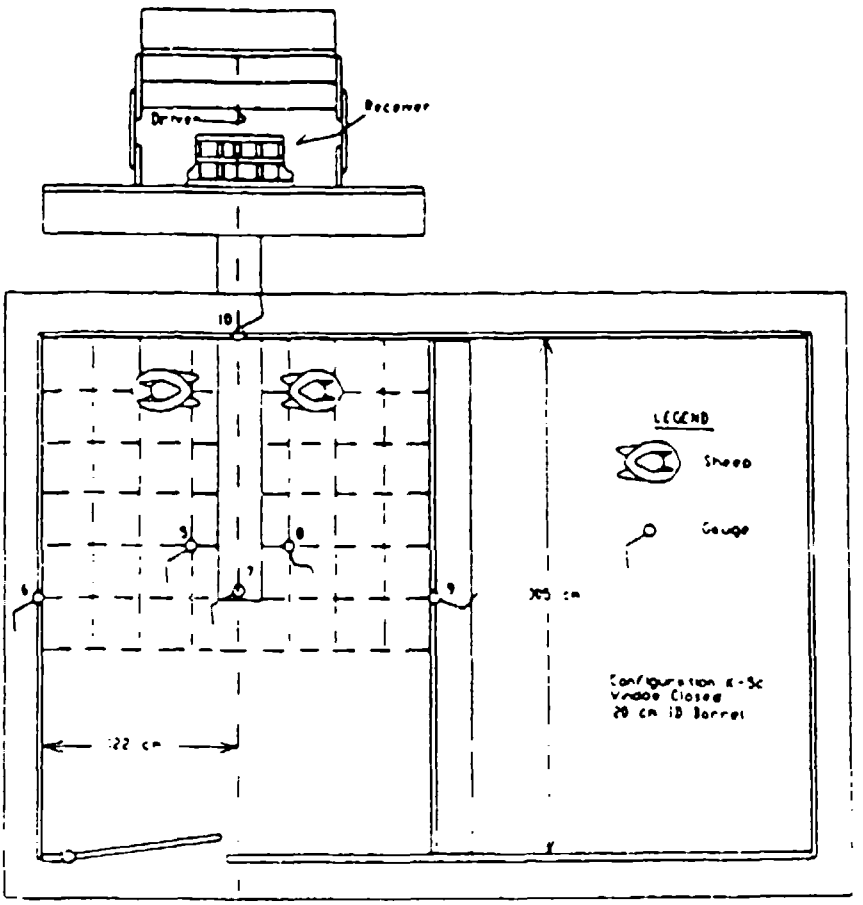
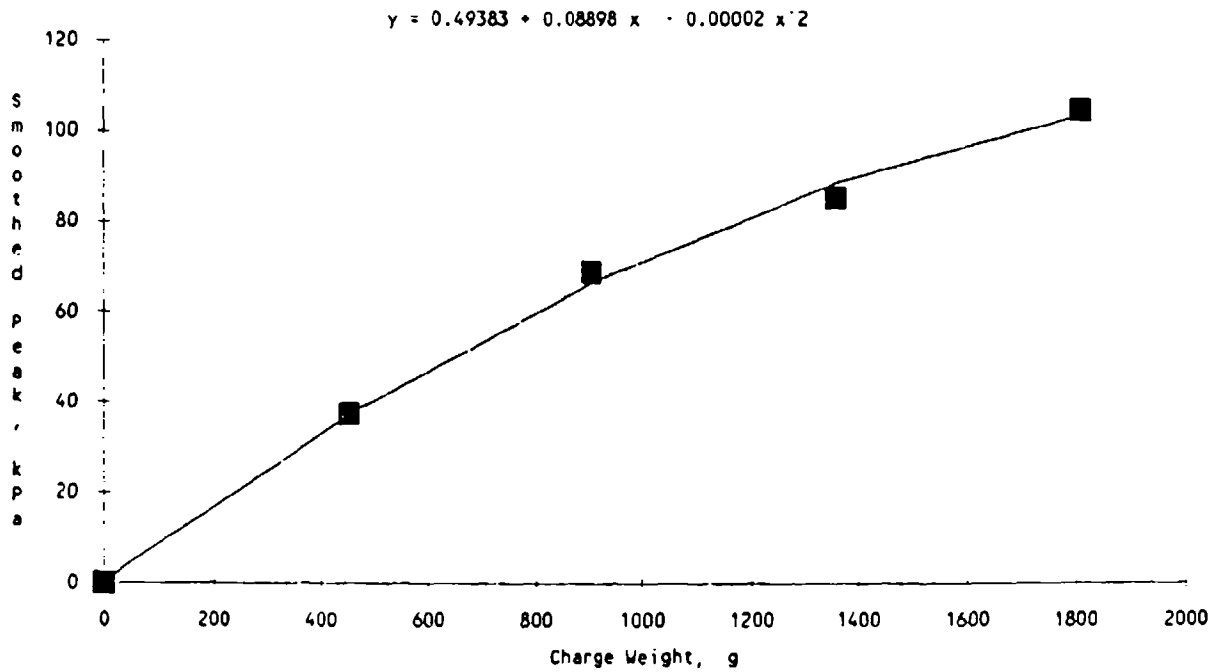


Figure 3. Gauge layout and animal locations for the Carl-Gustav simulation tests in the 3.05 x 2.44 x 2.44-m enclosure.

Figure 4. Preliminary instrumentation cylinder calibration curve for experimental design for the Carl-Gustav blast simulation in the 3.05 x 2.44 x 2.44- m enclosure.



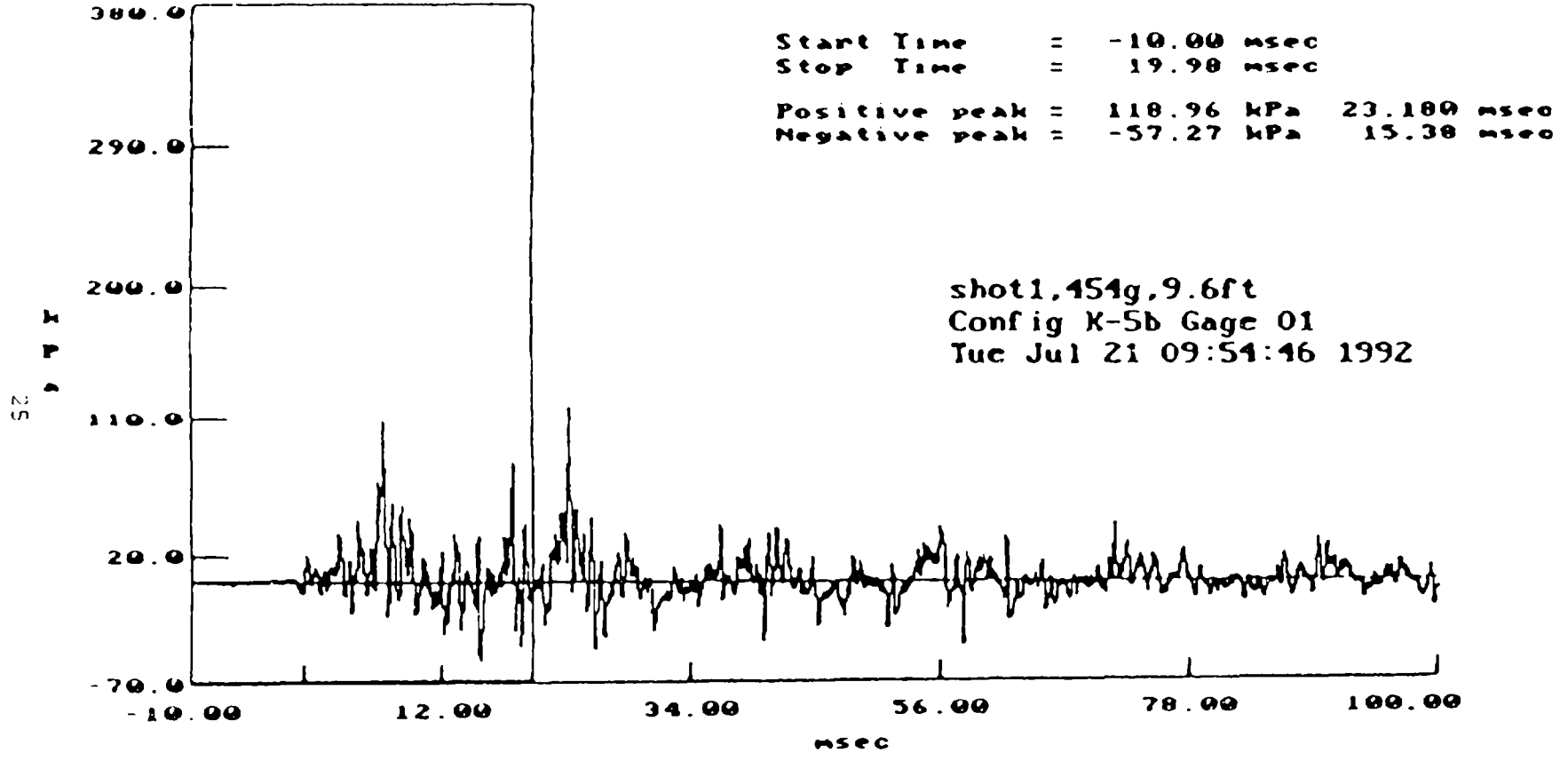


Figure 5. Gauge one pressure-time pattern from a 454-g charge detonation in the 3.05 x 2.44 x 2.44- m Carl-Gustav anti-tank weapon blast simulator.

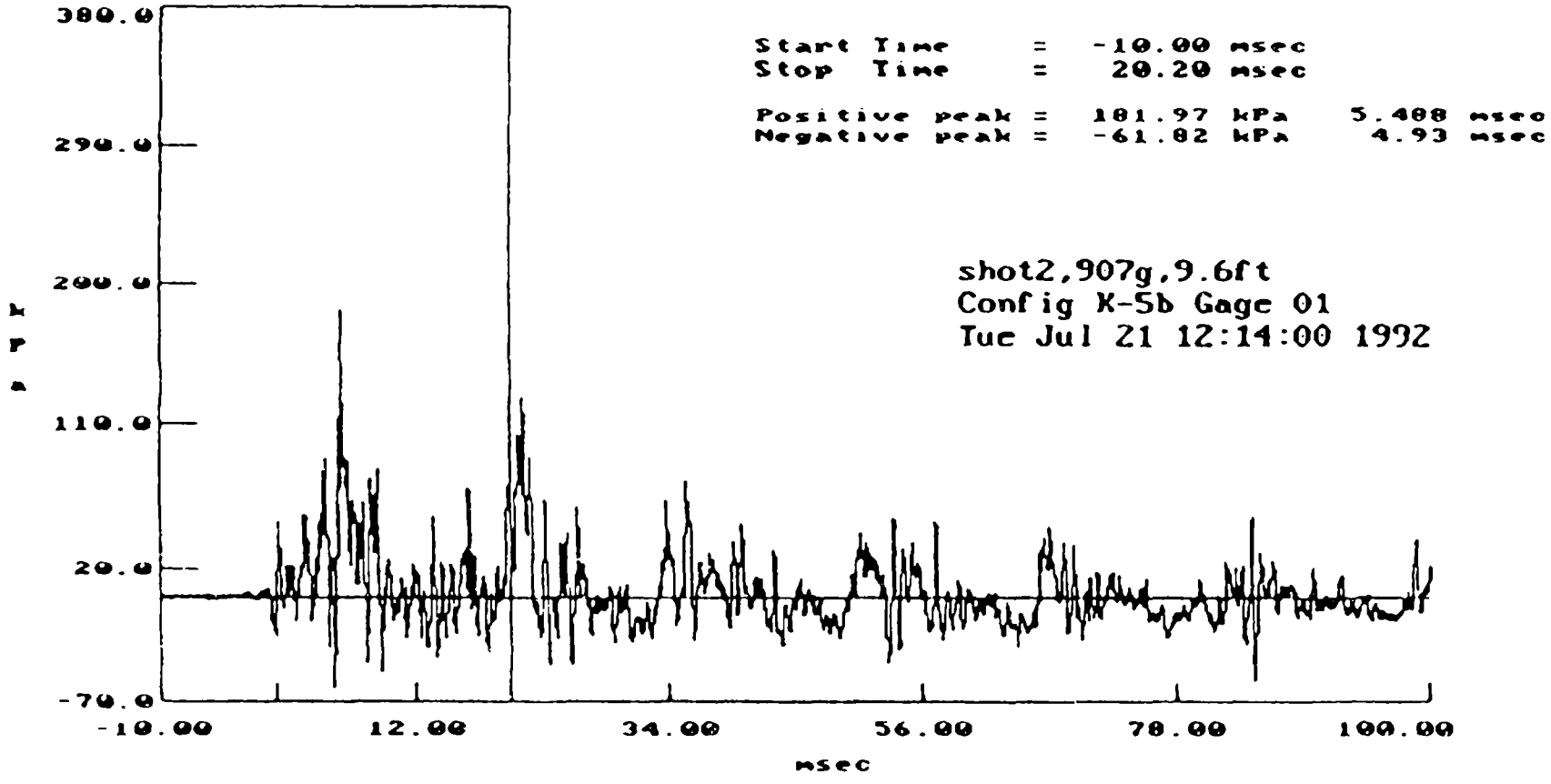


Figure 6. Gauge one pressure-time pattern from a 907-g charge detonation in the 3.05 x 2.44 x 2.44- m Carl-Gustav anti-tank weapon blast simulator.

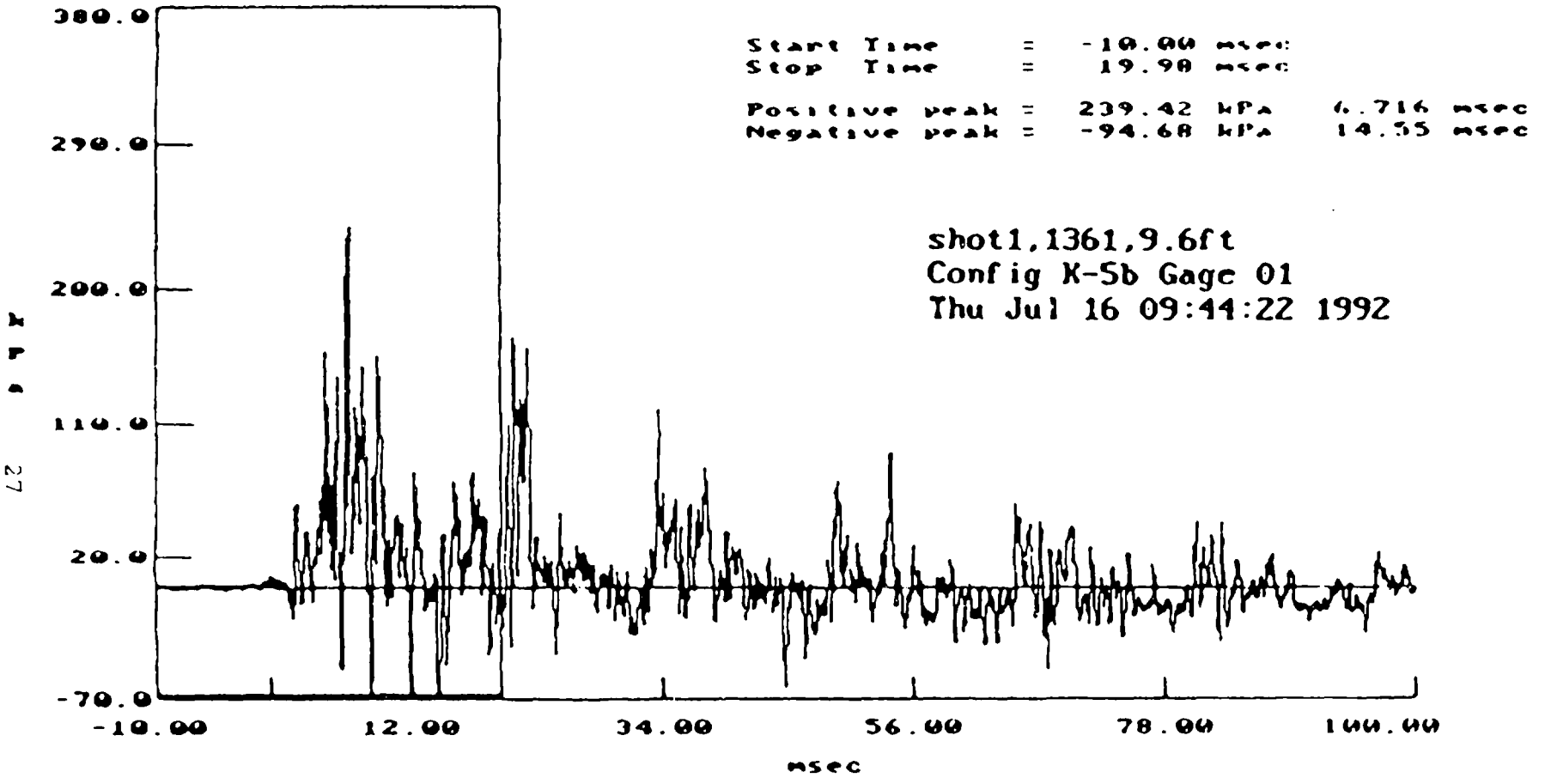


Figure 7. Gauge one pressure-time pattern from a 1361-g charge detonation in the 3.05 x 2.44 x 2.44- m Carl-Gustav anti-tank weapon blast simulator.

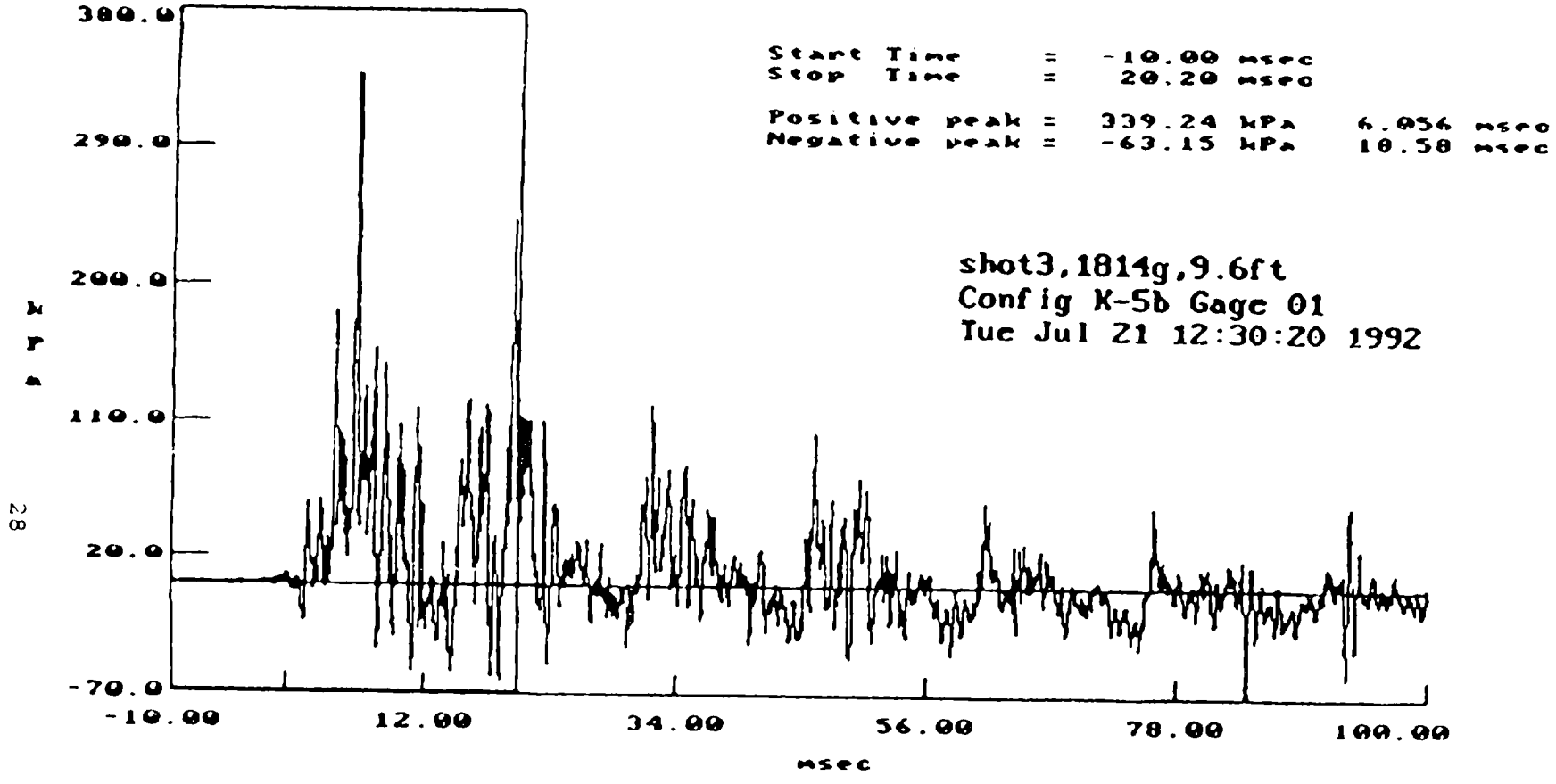


Figure 8. Gauge one pressure-time pattern from a 1814-g charge detonation in the 3.05 x 2.44 x 2.44- m Carl-Gustav anti-tank weapon blast simulator.

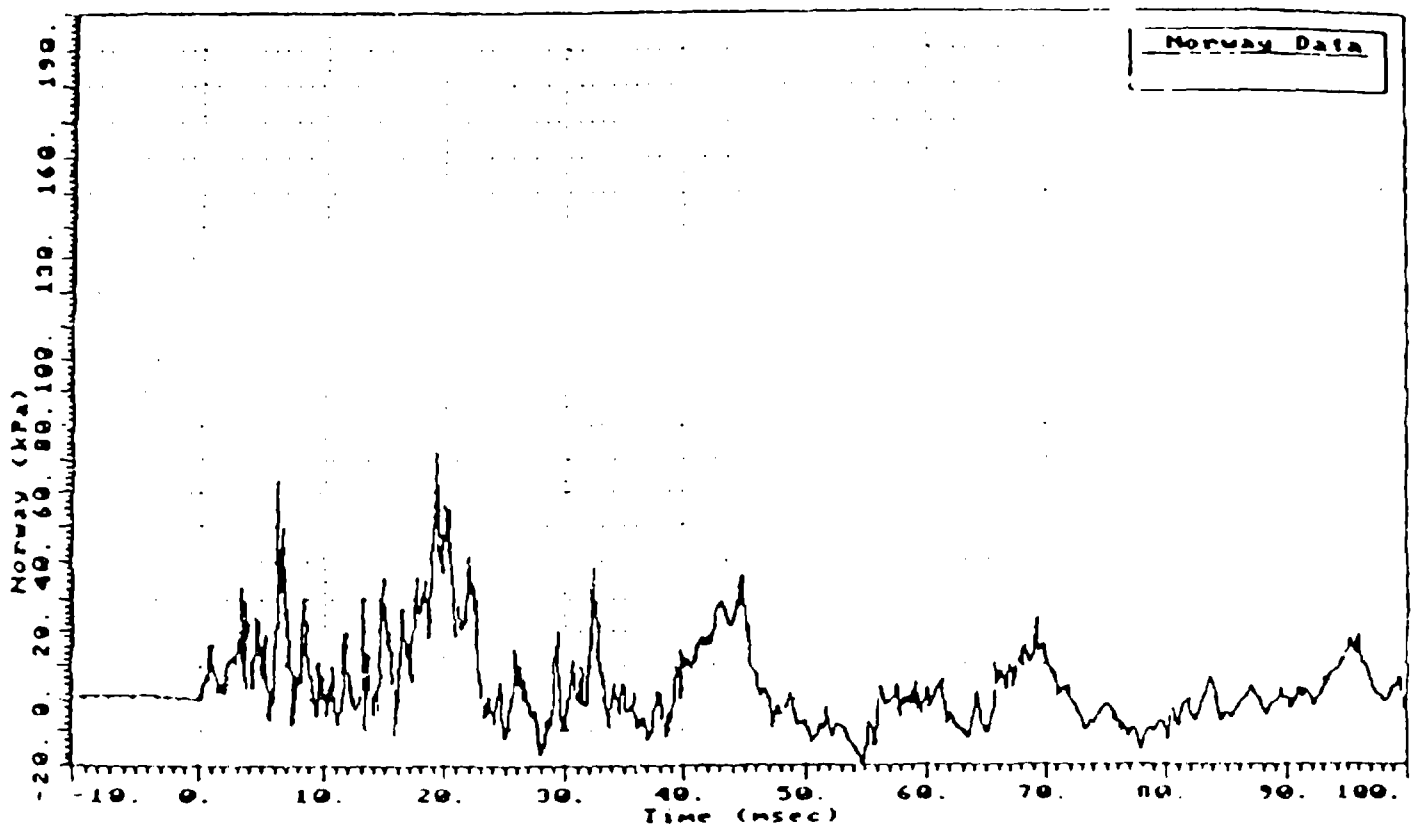


Figure 9. Pressure-time pattern recorded at operator's position of a Carl-Gustav anti-tank weapon. Provided by the WRAIR, courtesy of Norwegian Defence Construction Service.

Figure 10 . Mean maximum peak pressure (Pmax) versus charge weight calibration curve for gauges 1, 2, 3 and 4 of the instrument cylinder.

$y = 16.7225883 + 0.1264033x + 0.0000144x^2$

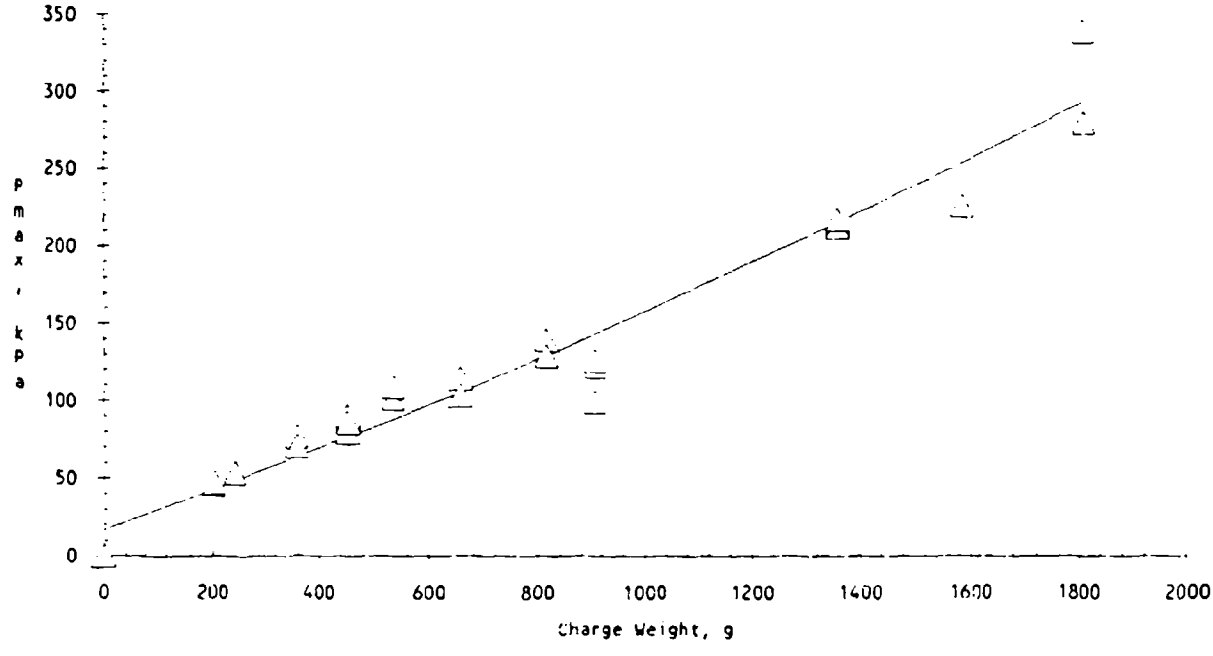


Figure 11. Mean smoothed peak pressure (Psm) versus charge weight calibration curve for gauges 1, 2, 3 and 4 of the instrument cylinder.

$y = 4.2147674 + 0.0786800x - 0.0000117x^2$

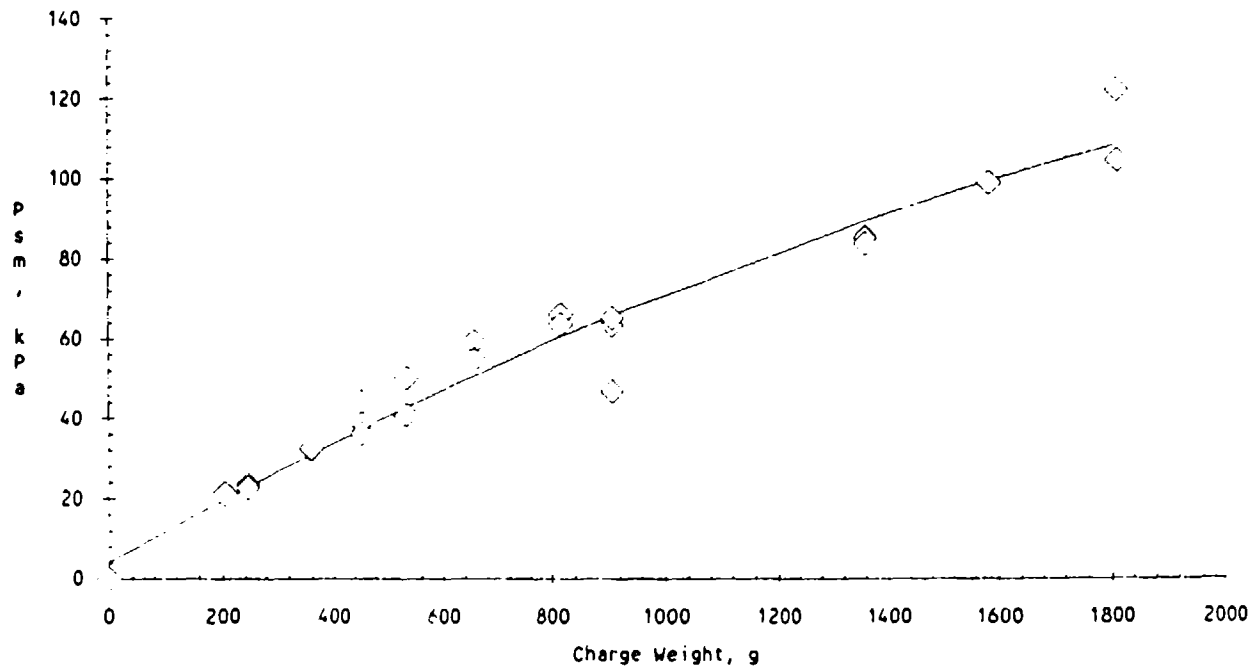


Figure 12. Relationship between the maximum peak pressures (Pmax) recorded in the enclosure and the calculated smoothed peak pressures (Psm) using the mean values for gauges 1, 2 , and 4 of the instrumentation cylinder.

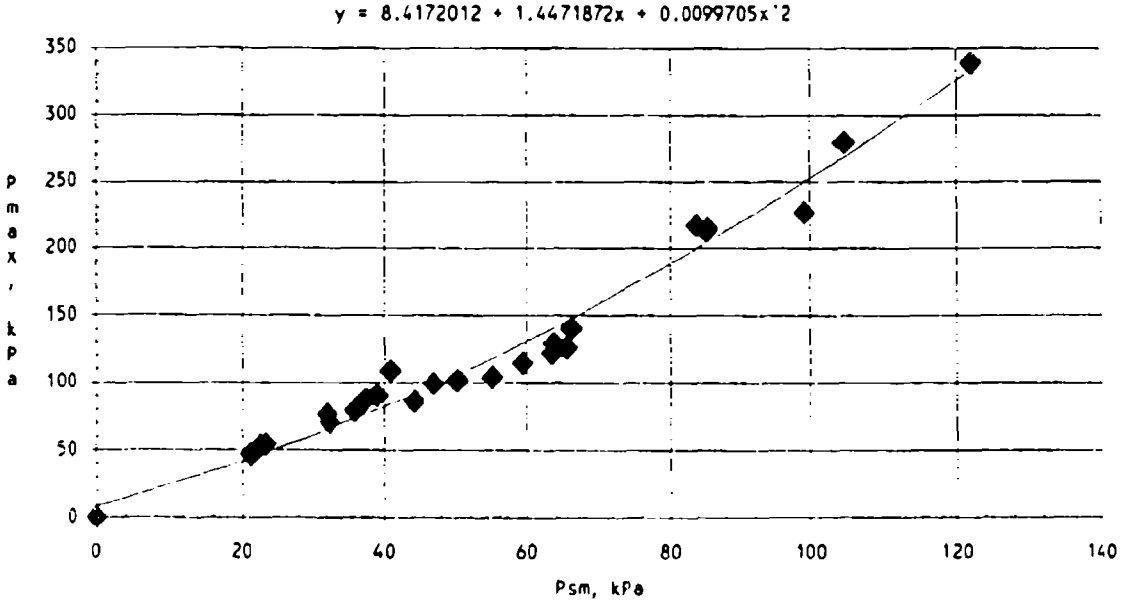


Figure 13. Mean severity of injury indices as a function of the instrumentation cylinder smoothed peak pressure (Psm) for 12 exposures to a simulated Carl-Gustav blast wave in the 3.05 x 2.44 x 2.44- m enclosure.
y = -0.5920114 + 0.0281095x + 0.0000406x^2

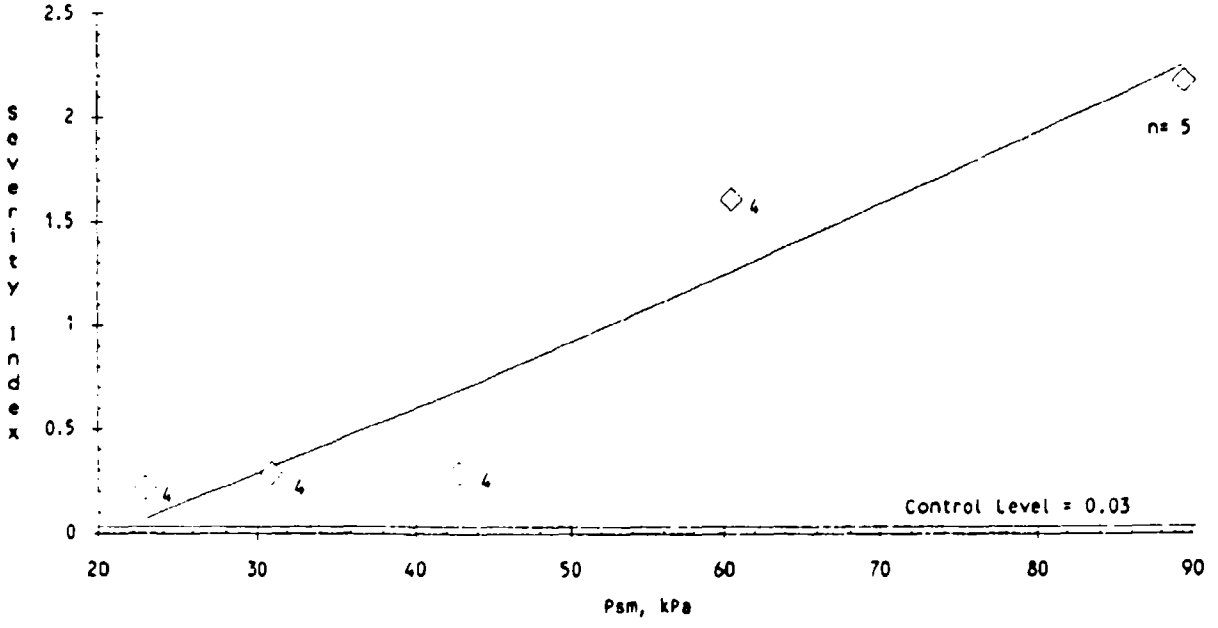


Figure 14. Mean severity of injury indices as a function of the instrumentation cylinder smoothed peak pressure (Psm) for one exposure to a simulated Carl-Gustav blast wave in the 3.05 x 2.44 x 2.44-m enclosure.

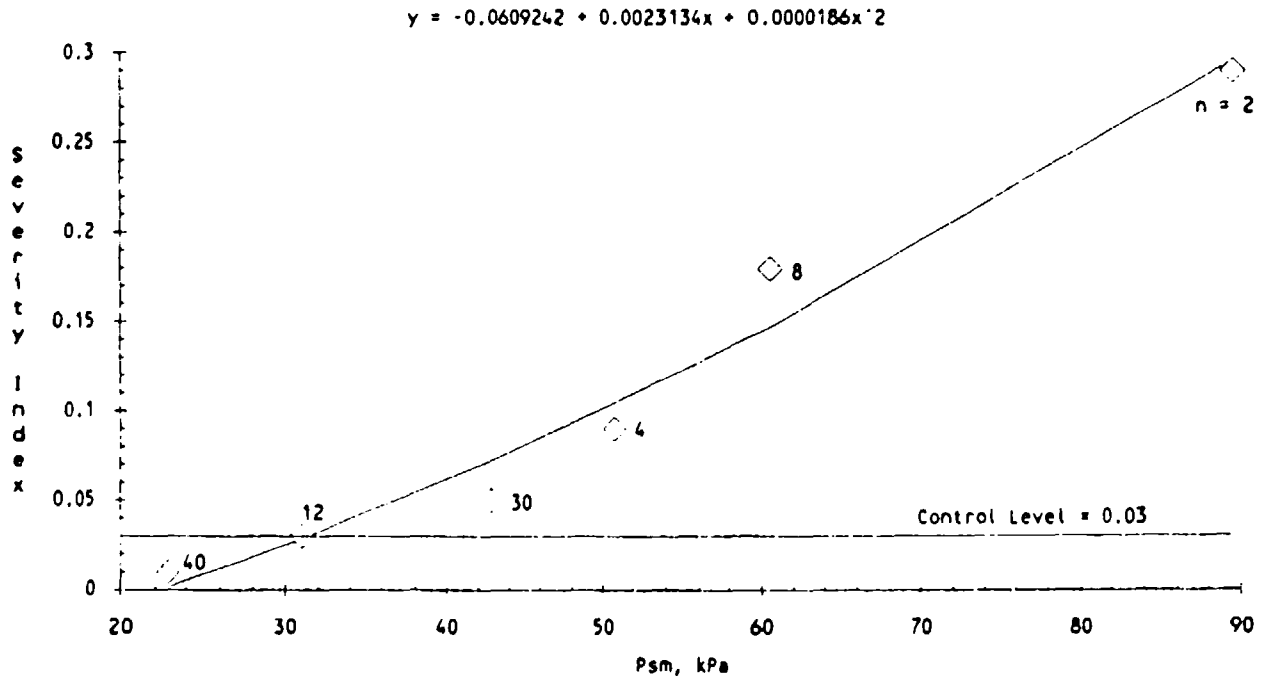


Figure 15. Mean severity of injury indices as a function of the instrumentation cylinder smoothed peak pressure (Psm) for three exposures to a simulated Carl-Gustav blast wave in the 3.05 x 2.44 x 2.44- m enclosure.

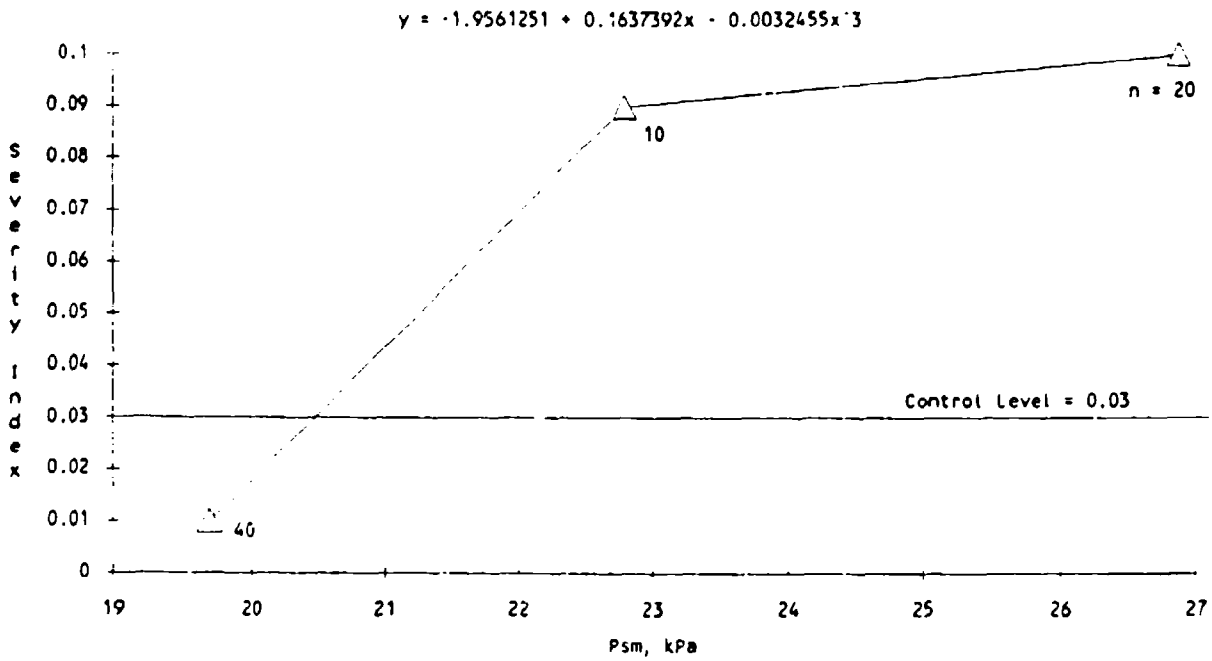


Figure 16. Smoothed peak pressure injury prediction curve for complex blast waves generated by detonating explosive charges in 11.3-, 18.2-, and 36.3-m^3 enclosures.

df = 51 y = -0.2490883 + 0.0035331x + 0.0000256x^2 Lethality = (r/n)

SS(res) = 51.42 Correl. Coef. = 0.8518 r^2 = 0.7255 t = 11.6109 p < 0.001

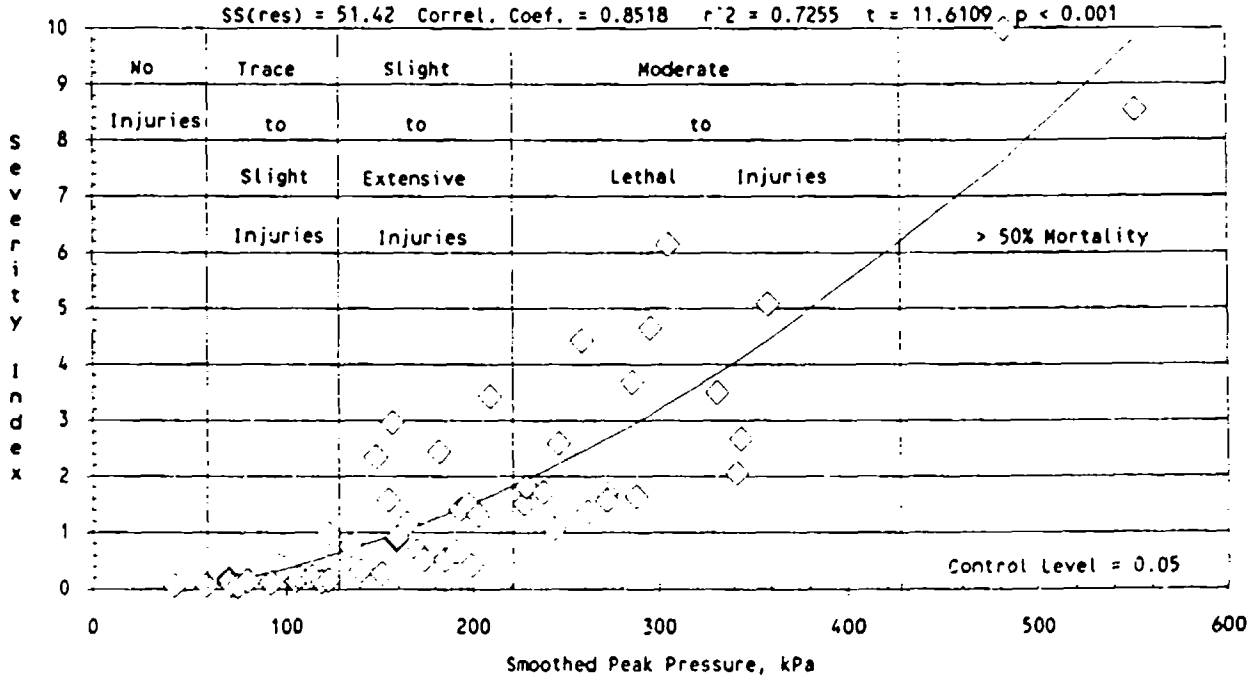


Table 1. Experimental design for the Carl-Gustav simulation tests in the 3.05 x 2.44 x 2.44- m configuration of the EG&G Test Enclosure.

Exposure Levels				Groups		
Delta db	Pmax, kPa	Psm, kPa	Charge Weight, g	Number of Animals/Number of Exposures 1	3	12
0	224.4	84.6	1361	2		5
3	134.2	59.8	816	8		4
4.5	108.9	50.3	656	4		
6	89.8	42.2	533	30		4
7.5	74.9	35.5	436			
9	63.2	29.9	359	12		4
10.5	54.6	25.6	302		20	
12	46.1	21.1	245	40	10	4
13.5	39.9	17.7	203		40	
			Subtotals	96	70	21
			Controls	14	12	8
			Totals	110	82	29

Equations from Preliminary Calibration Curves

Pmax = 10.31854 + 0.14370x + 0.00001x^2 where x = charge weight

Psm = 0.49383 + 0.08098x - 0.00002x^2 where x = charge weight

Table 2. Mean severity of injury indices (SI) versus instrument cylinder maximum and smoothed peak pressures and charge weight.

Exposure Levels				Exposure Groups		
Pmax, kPa	Psm, kPa	Charge Weight, g		Mean SI per Group and Level x1	x3	x12
215.4	89.7	1361		0.29		2.18
129.5	60.6	816		0.18		1.61
105.8	50.8	656		0.09		
88.2	42.8	533		0.05		0.29
64.0	31.0	359		0.03		0.29
56.2	26.9	302			0.10	
48.6	22.8	245		0.01	0.09	0.22
43.0	19.7	203			0.01	
		Controls		0.03		

Equations from Final Calibration Curves

Pmax = 16.7225883 +0.1264033x +0.0000144x^2 where x = charge weight

Psm = 4.2147674 + 0.0786800x - 0.0000117x^2 where x = charge weight

Table 3. Mean severity of injury indices (SI) versus wall gauge number 10 maximum and smoothed peak pressures and charge weight.

	Pressure Level		Mean SI	Pressure Level		Mean SI	Pressure Level		Mean SI
Charge Weight, g	Pmax, kPa	Psm, kPa	for One Exposure	Pmax, kPa	Psm, kPa	for Three Exposures	Pmax, kPa	Psm, kPa	for Twelve Exposures
1361	141.1	88.3	0.29				563.90	110.10	2.18
816	131.4	68.4	0.18				130.40	63.00	1.61
656	169.5	58.2	0.09						
533	111.6	45.3	0.05				82.60	42.10	0.29
359	60.6	32.8	0.03				54.70	30.10	0.29
302				48.90	22.60	0.10			
245	40.4	22.0	0.01	43.10	21.50	0.09	39.50	21.60	0.22
203				38.20	17.60	0.01			
Controls			0.03						

APPENDIX A

MAXIMUM PEAK PRESSURES

Table A-1. Maximum peak pressure (Pmax) records from the Carl-Gustav simulated blast wave calibration shots in the 3.05 x 2.44 x 2.44- m enclosure.

Date	Charge Wt., g	Shot No.	G1	G2	G3	G4	G1,2,4 Mean	G2-4 Mean	G1-4 Mean	G5	G6	G7	G8	G9	G10	Tube
			Maximum Peak (Pmax), kPa													
10/30/92	203	c67	51.8	50.6	34.3	49.3	50.6	50.0	46.5	56.1	85.7		39.7	66.2	35.9	1368.9
10/30/92	203	c68	53.9	48.3	40.8	46.9	49.7	47.6	47.5	43.6	80.6		39.2	69.6	35.9	1647.9
8/25/92	227	s01c66					0.0	0.0		47.1	73.4		53.3	70.6	37.5	1385.0
8/25/92	227	s02c66					0.0	0.0		39.3	80.9		52.7	58.0	42.3	1569.4
8/25/92	227	s03c66					0.0	0.0		39.3	92.7		35.7	68.7	40.9	1353.3
8/19/92	227	c62*	82.5	48.9	36.7	44.0	58.5	46.5	53.0	37.0	99.2	42.3	39.4	78.2	46.6	
10/30/92	245	c69	75.7	44.9	48.8	47.8	56.1	46.4	54.3	54.1	97.9		51.5	72.8	46.0	1961.6
10/30/92	245	c70	75.8	38.5	60.4	40.0	51.4	39.3	53.7	62.2	102.7		47.2	94.9	47.2	1522.7
10/30/92	359	c71	93.3	76.6	63.5	74.5	81.5	75.6	77.0	71.1	193.8		62.4	154.7	61.4	2131.5
10/30/92	359	c72	91.3	77.4	53.8	61.1	76.6	69.3	70.9	55.2	167.3		50.2	140.4	51.7	2387.0
7/21/92	454	c51	119.0	99.9	74.5	57.7	92.2	78.8	87.8							
8/6/92	454	c55	109.2	106.1	69.8	76.6	97.3	91.4	90.4	74.5	159.6	72.2	71.0	176.6	101.7	
8/6/92	454	c56	100.8	91.2	69.6	57.7	83.2	74.5	79.8	83.9	156.3	68.5	74.2	200.2	115.4	
10/30/92	454	c73	121.1	75.5	79.1	69.7	88.8	72.6	86.4	76.3	168.2		65.9	219.2	81.2	3134.7
10/30/92	533	c74	147.8	92.3	100.9	66.8	102.3	79.6	102.0	73.6	180.6		131.0	268.8		3242.5
10/30/92	533	c75	180.1	82.5		64.4	109.0	73.5	109.0	89.4	193.8		112.8	227.8	113.7	3163.2
10/30/92	656	c76	168.4	100.4	124.6	66.6	111.8	83.5	115.0	110.3	185.4		93.6	189.4	154.8	3538.9
10/30/92	656	c77	143.4	106.5	89.6	76.2	108.7	91.4	103.9	95.4	221.5		102.7	171.5	145.8	3599.7
10/30/92	816	c78	146.2	141.0	151.5	121.9	136.4	131.5	140.2	95.4	269.5		93.5	237.7	123.2	3479.4
10/30/92	816	c79	124.9	161.3	135.8	96.2	127.5	128.8	129.6	92.0	279.8		133.8	217.0	136.3	3024.3
7/21/92	907	c52	181.9		114.9	100.5	94.1	50.3	99.3							
8/6/92	907	c57	142.7	140.7	119.4	87.6	123.7	114.2	122.6	97.0	264.4	112.6	99.3	221.7	151.0	
8/6/92	907	c58	157.0	132.1	108.9	107.2	132.1	119.7	126.3	92.4	359.1	111.2	102.6	197.8	130.9	
8/19/92	1134	c63*	262.1	217.3	160.3	154.6	211.3	186.0	198.6	112.2	303.0	137.5	120.8	195.1	211.2	
7/16/92	1361	c49	239.4	169.0	260.7	191.6	200.0	180.3	215.2							
7/22/92	1361	c54**	308.0	252.2	236.2	158.0	239.4	205.1	238.6							
8/6/92	1361	c59	343.2	153.4	216.3	138.0	211.5	145.7	212.7	128.4	215.0	153.4	132.3	194.8	164.6	
8/6/92	1361	c60	346.5	157.7	228.4	137.3	213.8	147.5	217.5	134.9	166.9	162.7		206.5	198.5	
8/19/92	1588	c64	252.4	181.8	292.2	179.9	204.7	180.9	226.6	51.4	197.6	181.9	112.9	229.8		
7/21/92	1814	c53	339.2	189.1	410.8	180.5	236.3	184.8	279.9							
8/6/92	1814	c61	433.0	252.0	459.6	212.5	299.2	232.3	339.3	170.0	184.0	247.8	118.8	192.9	246.1	

* Vent doors were closed on both shots and not included in calibration shots.

** Instrumentation cylinder was rotated 45 degrees on this shot and not included in calibration shots.

Table A-2. Smoothed peak pressure (Psm) records from the Carl-Gustav simulated blast wave calibration shots in the 3.05 x 2.44 x 2.44- m enclosure.

Date	Charge Wt., g	Shot No.	G1	G2	G3	G4	G1,2,4 Mean	G2-4 Mean	G1-4 Mean	G5	G6	G7	G8	G9	G10	Tube
			Smoothed Peak (Psm), kPa													
10/30/92	203	c67	27.3	25.0	12.2	21.2	24.5	23.1	21.4	20.6	21.0		18.2	22.3	19.4	607.6
10/30/92	203	c68	27.0	24.3	12.6	20.7	24.0	22.5	21.2	21.1	21.7		19.4	22.2	18.5	618.8
8/25/92	227	s01c66					0.0	0.0		21.0	21.0		18.6	21.5	19.3	586.2
8/25/92	227	s02c66					0.0	0.0		20.2	22.0		20.0	22.3	19.4	599.2
8/25/92	227	s03c66					0.0	0.0		22.3	23.0		20.0	22.6	20.0	661.0
8/19/92	227	c62	38.1	33.2	19.0	23.6	31.6	28.4	28.5	23.5	23.6	24.4	24.7	24.2	25.2	
10/30/92	245	c69	29.8	27.2	15.4	21.4	26.1	24.3	23.5	24.7	24.8		20.7	23.8	20.5	664.6
10/30/92	245	c70	28.7	25.3	15.2	21.5	25.2	23.4	22.7	29.0	25.7		20.5	26.4	21.6	706.8
10/30/92	359	c71	45.0	30.4	21.9	31.5	35.6	31.0	32.2	36.5	36.8		28.0	37.1	32.8	982.1
10/30/92	359	c72	43.4	28.6	27.4	30.8	34.3	29.7	32.6	30.8	34.8		25.9	35.6	31.9	920.1
7/21/92	454	c51	43.9	47.1	29.3	29.8	40.3	38.5	37.5							
8/6/92	454	c55	49.2	42.5	30.9	33.4	41.7	38.0	39.0	36.8	42.1	44.3	34.6	44.4	41.2	
8/6/92	454	c56	41.7	41.9	30.1	31.1	38.2	36.5	36.2	46.6	40.1	44.0	34.6	43.4	38.1	
10/30/92	454	c73	58.8	39.9	41.6	36.8	45.2	38.4	44.3	37.4	40.8		32.8	43.1	40.6	1098.6
10/30/92	533	c74	70.0	54.8	38.0	38.1	54.3	46.5	50.2	40.4	47.8		42.8	51.7		1342.9
10/30/92	533	c75	72.7	52.9		37.8	54.5	45.4	40.9	40.6	46.3		38.3	50.0	43.3	1233.8
10/30/92	656	c76	74.4	62.4	64.3	36.6	57.8	49.5	59.4	46.2	53.0		47.0	55.3	54.6	1447.1
10/30/92	656	c77	77.2	64.1	40.5	37.9	59.7	51.0	54.9	50.9	53.1		47.7	52.7	52.4	1411.1
10/30/92	816	c78	81.7	64.9	71.3	46.3	64.3	55.6	66.1	51.7	61.1		55.1	58.8	64.6	1659.1
10/30/92	816	c79	77.4	62.2	68.9	46.5	62.0	54.4	63.8	51.9	60.9		55.5	61.4	66.8	1728.5
7/21/92	907	c52	80.9		58.4	48.6	43.2	24.3	47.0							
8/6/92	907	c57	77.5	66.1	60.1	50.2	64.6	58.2	63.5	70.0	60.3	68.3	59.8	62.8	70.9	
8/6/92	907	c58	87.6	62.5	59.1	52.1	67.4	57.3	65.3	68.3	61.5	67.6	59.4	60.7	69.4	
8/19/92	1134	c63	123.6	92.0	75.9	74.2	96.6	83.1	91.4	71.5	70.6	84.2	67.7	71.4	97.6	
7/16/92	1361	c49	110.3	73.4	84.2	73.9	85.9	73.7	85.5							
7/22/92	1361	c54	104.0	106.2	89.4	70.5	93.6	88.4	92.5							
8/6/92	1361	c59	115.5	69.6	79.5	76.4	87.2	73.0	85.3	97.8	72.5	89.2	66.2	73.4	87.0	
8/6/92	1361	c60	112.9	69.6	78.4	74.3	85.6	72.0	83.8	91.4	75.9	85.8		72.3	90.0	
8/19/92	1588	c64	130.1	83.2	97.6	85.5	99.6	84.4	99.1	40.2	82.2	85.8	53.4	90.3		
7/21/92	1814	c53	125.7	87.5	103.1	101.8	105.0	94.7	104.5							
8/6/92	1814	c61	138.5	98.1	142.0	109.8	115.5	104.0	122.1	105.9	84.9	99.3	69.7	92.1	117.2	

* Vent doors were closed on both shots and not included in calibration shots.
** Instrumentation cylinder was rotated 45 degrees on this shot and not included in calibration shots.

APPENDIX B

PATHOLOGY SUMMARY

Table B-1. Pathology summary for the simulated weapon experiments in the 3.05 x 2.44 x 2.44- m enclosure.

DATE	ANIMAL	CHARGE WT., g	LW/BW, %	LUNGS		PHARYNX/ LARYNX		TRACHEA		GI TRACT		SOLID AB. ORGANS		ADI. SEV. INDEX	RIGHT EAR RUPT'E	RIGHT EAR SCORE	LEFT EAR RUPT'E	LEFT EAR SCORE	PROTEC- TION
					12 EXPOSURES														
8/31/92	281	1361	1.04	TRACE	3	SL	6	MOD	20	SL	9	NEG	0	0.70	0%	0	0%	0	MUFF
9/3/92	284	1361	0.96	SL	5	SL	16	MOD	20	SL	10	SL	12	4.28	0%	0	0%	0	EAR
9/3/92	285	1361	0.90	TRACE	3	SL	14	EXT	40	SL	7	NEG	0	1.34	0%	0	0%	0	EAR
9/10/92	286	1361	0.84	TRACE	3	MOD	22	EXT	44	MOD	24	TRACE	4	2.89	75%	5	0%	0	IP
9/10/92	287	1361	DISEASE	NA		SL	12	SL	7	SL	9	TRACE	3	1.71	100%	21	100%	21	NONE
MEAN	n = 5		0.94		3.5		14		26		12		3.3	2.18		5.2		4.2	
SD			0.09		1.0		5.8		15		6.9		4.9	1.42		9.1		9.4	
SE			0.04		0.5		2.6		6.9		3.1		2.2	0.63		4.1		4.2	
9/16/92	292	816	1.05	TRACE	4	SL	7	SL	7	SL	18	NEG	0	0.76	0%	0	0%	0	EAR
9/16/92	293	816	DISEASE	NA		SL	7	SL	6	MOD	24	SL	6	1.86	0%	0	0%	0	EAR
9/17/92	294	816	0.99	TRACE	4	TRACE	3	SL	6	MOD	24	NEG	0	1.72	100%	12	100%	12	NONE
9/17/92	295	816	0.94	SL	10	SL	5	SL	18	MOD	22	NEG	0	2.11	50%	12	100%	12	NONE
MEAN	n = 4		0.99		6.0		5.5		9.3		22		1.5	1.61		6.0		6.0	
SD			0.06		3.5		1.9		5.9		2.8		3.0	0.59		6.9		6.9	
SE			0.03		2.0		1.0		2.9		1.4		1.5	0.30		3.5		3.5	
9/18/92	296	533	0.89	NEG	0	TRACE	4	SL	7	SL	7	NEG	0	0.34	0%	0	0%	0	EAR
9/18/92	297	533	DISEASE	NA		SL	8	SL	9	TRACE	3	NEG	0	0.44	0%	0	0%	0	EAR
9/21/92	298	533	0.89	NEG	0	SL	5	SL	7	NEG	0	NEG	0	0.21	0%	0	100%	12	NONE
9/21/92	299	533	0.98	NEG	0	TRACE	3	SL	7	NEG(b,o)	0	NEG	0	0.18	75%	5	0%	0	NONE
MEAN	n = 4		0.92		0.0		5.0		7.5		2.5		0.0	0.29		1.3		3.0	
SD			0.05		0.0		2.2		1.0		3.3		0.0	0.12		2.5		6.0	
SE			0.03		0.0		1.1		0.5		1.7		0.0	0.06		1.3		3.0	
9/23/92	300	359	0.85	NEG	0	TRACE	3	SL	7	NEG	0	NEG	0	0.18	0%	0	0%	0	EAR
9/23/92	301	359	1.05	NEG	0	TRACE	3	TRACE	3	SL	6	NEG	0	0.23	0%	0	0%	0	EAR
11/3/92	330	359	0.95	TRACE	3	TRACE	3	TRACE	8	TRACE	3	NEG	0	0.30	100%	8	40%	4	NONE
11/3/92	331	359	0.83	NEG	0	TRACE	3	SL	18	TRACE	4	NEG	0	0.46	75%	8	30%	4	NONE
MEAN	n = 4		0.92		0.8		3.0		9.0		3.3		0.0	0.29		4.0		2.0	
SD			0.10		1.5		0.0		6.4		2.5		0.0	0.12		4.6		2.3	
SE			0.05		0.8		0.0		3.2		1.3		0.0	0.06		2.3		1.2	
9/25/92	304	245	0.99	TRACE	4	TRACE	3	NEG	0	SL	16	NEG	0	0.45	0%	0	75%	5	NONE
9/25/92	305	245	1.12	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	75%	5	0%	0	NONE
10/16/92	320	245	1.01	NEG	0	NEG	0	SL	7	NEG	0	NEG	0	0.13	1%	3	0%	0	NONE
10/16/92	321	245	1.12	NEG	0	NEG	0	SL	6	SL	8	NEG	0	0.28	0%	0	0%	0	EAR
MEAN	n = 4		1.06		1.0		0.8		3.3		6.0		0.0	0.22		2.0		3	
SD			0.07		2.0		1.5		3.8		7.7		0.0	0.19		2.4		2.5	
SE			0.03		1.0		0.8		1.9		3.8		0.0	0.10		1.2		1.3	

Table 8-1(cont'd). Pathology summary for the simulated weapon experiments in the 3.05 x 2.44 x 2.44- m enclosure.

DATE	ANIMAL	CHARGE WT., g	LW/BW, %	LUNGS		PHARYNX/ LARYNX		TRACHEA		GI TRACT		SOLID AB. ORGANS		ADJ.SEV. INDEX	RIGHT EAR RUPT'E	RIGHT EAR SCORE	LEFT EAR RUPT'E	LEFT EAR SCORE	PROTEC-TION
				SINGLE EXPOSURES															
9/29/92	306	1361	1.20	SL	8	SL	5	NEG	0	TRACE	3	NEG	0	[illegible]	0%	0	0%	0	EAR
9/29/92	307	1361	1.12	TRACE	3	SL	7	TRACE	3	TRACE	4	NEG	0	[illegible]	0%	0	0%	0	EAR
MEAN	n = 2		1.16		5.5		6.0		1.5		3.5		0.0	0.29		0.0		0.0	
SD			0.06		3.5		1.4		2.1		0.7		0.0	0.02		0.0		0.0	
SE			0.04		2.5		1.0		1.5		0.5		0.0	0.01		0.0		0.0	
9/30/92	308	816	1.05	NEG	0	TRACE	3	NEG	0	NEG(a)	0	NEG	0	0.05	0%	0	0%	0	EAR
9/30/92	309	816	1.21	TRACE	4	TRACE	3	SL	5	NEG	0	NEG	0	0.20	0%	0	0%	0	EAR
10/27/92	326	816	0.98	TRACE	4	TRACE	4	SL	5	NEG	0	NEG	0	0.22	5%	4	50%	5	NONE
10/27/92	327	816	0.82	NEG	0	TRACE	4	NEG	0	TRACE	4	NEG	0	0.15	0%	0	5%	10	NONE
11/10/92	332	816	0.95	TRACE	4	TRACE	4	SL	5	SL	6	NEG	0	0.35	0%	0	0%	0	EART
11/10/92	333	816	0.86	NEG	0	TRACE	3	SL	6	NEG(b)	0	NEG	0	0.16	0%	0	0%	0	EART
11/11/92	334	816	0.85	NEG	0	TRACE	4	NEG	0	NEG	0	NEG	0	0.07	0%	0	10%	4	EART
11/11/92	335	816	DISEASE	NEG		SL	5	TRACE	3	TRACE	3	NEG	0	0.20	0%	0	0%	0	EART
MEAN	n = 8		0.96		1.7		3.8		3.0		1.6		0.0	0.18		0.5		2.4	
SD			0.14		2.1		0.7		2.6		2.4		0.0	0.09		1.4		3.7	
SE			0.05		0.8		0.3		0.9		0.8		0.0	0.03		0.5		1.3	
11/12/92	336	656	1.03	NEG	0	SL	5	TRACE	3	NEG(b)	0	NEG	0	0.14	30%	4	5%	4	EAR(c)
11/12/92	337	656	0.91	NEG	0	TRACE	3	SL	5	NEG	0	NEG	0	0.14	0%	0	0%	0	EAR
11/17/92	338	656	0.95	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	EART
11/17/92	339	656	0.88	NEG	0	TRACE	4	NEG	0	NEG(b)	0	NEG	0	0.07	0%	0	0%	0	EART
MEAN	n = 4		0.94		0.0		3.0		2.0		0.0		0.0	0.09		1.0		1.0	
SD			0.07		0.0		2.2		2.4		0.0		0.0	0.07		2.0		2.0	
SE			0.03		0.0		1.1		1.2		0.0		0.0	0.03		1.0		1.0	
10/8/92	312	533	0.85	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
10/8/92	313	533	1.04	NEG	0	NEG	0	NEG	0	TRACE	4	NEG	0	0.08	0%	0	0%	0	EAR
10/23/92	324	533	0.87	TRACE	3	NEG	0	NEG	0	NEG	0	NEG	0	0.05	30%	4	0%	0	NONE
10/23/92	325	533	0.94	NEG	0	SL(d)	5	NEG	0	NEG	0	NEG	0	0.06	60%	4	5%	4	NONE
11/19/92	340(h)	533	0.82	NEG	0	NEG	0	NEG	0	NEG(o)	0	NEG	0	0.00	1%	4	0%	0	EART(c)
11/19/92	341	533	1.02	NEG	0	NEG	0	NEG(i)	0	NEG(b)	0	NEG	0	0.00	(g)	4	0%	0	EART(f)
11/20/92	342	533	0.78	NEG	0	SL(j)	5	TRACE	3	NEG	0	NEG	0	0.14	0%	0	0%	0	EART
11/20/92	343	533	0.94	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	EART
11/24/92	344	533	0.95	NEG	0	NEG	0	NEG	0	NEG(b,o)	0	NEG	0	0.00	0%	0	0%	0	EAR
11/24/92	345	533	0.82	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	EAR
11/25/92	346	533	1.10	NEG	0	NEG	0	NEG	0	NEG(o)	0	NEG	0	0.00	50%	4	50%	4	NONE
11/25/92	347	533	0.82	NEG	0	NEG	0	SL	5	NEG	0	NEG	0	0.09	40%	4	0%	0	NONE
12/1/92	348	533	1.07	NEG	0	TRACE	3	TRACE	3	TRACE	3	NEG	0	0.17	1%	3	0%	0	BFP
12/1/92	349	533	DISEASE	NA		NEG	0	NEG	0	NEG(o)	0	NEG	0	0.00	0%	0	0%	0	BFP

Table B-1(cont'd). Pathology summary for the simulated weapon experiments in the 3.05 x 2.44 x 2.44- m enclosure.

DATE	ANIMAL	CHARGE WT., g	LW/BW, %	LUNGS		PHARYNX/ LARYNX		TRACHEA		GI TRACT		SOLID AB. ORGANS		ADJ.SEV. INDEX	RIGHT EAR RUPT'E	RIGHT EAR SCORE	LEFT EAR RUPT'E	LEFT EAR SCORE	PROTEC-TION
12/3/92	352	533	0.88	NEG	0	NEG	0	NEG(i)	0	NEG	0	NEG	0	0.00	1%	3	0%	0	BFP
12/3/92	353	533	0.91	NEG	0	NEG	0	SL	5	NEG	0	NEG	0	0.09	0%	0	0%	0	BFP
12/7/92	354	533	0.97	NEG	0	NEG	0	NEG	0	TRACE	3	NEG	0	0.06	0%	0	0%	0	EAR
12/7/92	355	533	1.07	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
12/16/92	356	533	0.97	NEG	0	NEG	0	TRACE	4	NEG	0	NEG	0	0.07	0%	0	0%	0	EART
12/16/92	357	533	0.92	NEG	0	NEG	0	SL	5	NEG	0	NEG	0	0.09	0%	0	0%	0	EART
12/18/92	358	533	0.95	NEG	0	NEG	0	SL	5	NEG	0	NEG	0	0.09	10%	4	0%	0	NONE
12/18/92	359	533	0.96	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	50%	5	100%	12	NONE
1/5/93	360	533	0.81	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	10%	4	BFP
1/5/93	361	533	1.22	NEG	0	TRACE	3	SL	5	NEG	0	NEG	0	0.14	0%	0	0%	0	BFP
1/7/93	364	533	0.96	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	EAR
1/7/93	365	533	1.05	NEG	0	NEG	0	SL	5	NEG(b)	0	NEG	0	0.09	0%	0	0%	0	EAR
1/8/93	366	533	DISEASE	NA	0	NEG	0	SL	5	NEG	0	NEG	0	0.09	0%	0	0%	0	EART
1/8/93	367	533	0.91	NEG	0	TRACE	3	NEG	0	SL	6	NEG	0	0.18	0%	0	0%	0	EART
1/12/93	368	533	0.95	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	2	90%	5	NONE
1/12/93	369	533	0.87	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	2%	8	100%	5	NONE
MEAN	n = 30		0.94		0.1		0.6		1.5		0.5		0.0	0.05		1.6		1.1	
SD			0.10		0.6		1.5		2.2		1.5		0.0	0.06		2.2		2.6	
SE			0.02		0.1		0.3		0.4		0.3		0.0	0.01		0.4		0.5	
10/9/92	314	359	1.05	NEG	0	NEG	0	TRACE	3	NEG	0	NEG	0	0.05	0%	0	0%	0	EAR
10/9/92	315	359	0.95	SL	5	NEG	0	NEG	0	NEG	0	NEG	0	0.08	0%	0	0%	0	EAR
10/21/92	322	359	0.91	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
10/21/92	323	359	0.96	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
3/2/93	406	359	0.86	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
3/2/93	407	359	1.09	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
3/3/93	408	359	0.87	NEG	0	NEG	0	NEG(m)	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
3/3/93	409	359	0.87	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
3/4/93	410	359	1.09	NEG	0	NEG	0	NEG	0	NEG(o)	0	NEG	0	0.00	0%	0	0%	0	EAR
3/4/93	411	359	0.96	NEG	0	TRACE	4	NEG	0	NEG(b)	0	NEG	0	0.07	0%	0	0%	0	EAR
3/10/93	412	359	1.13	NEG(n)	0	NEG	0	NEG	0	TRACE	4	NEG	0	0.08	0%	2	0%	0	NONE
3/10/93	413	359	0.95	NEG	0	NEG	0	NEG	0	TRACE	3	NEG	0	0.06	0%	0	0%	0	NONE
MEAN	n = 12		0.97		0.4		0.3		0.3		0.6		0.0	0.03		0.2		0.0	
SD			0.09		1.4		1.2		0.9		1.4		0.0	0.04		0.6		0.0	
SE			0.03		0.4		0.3		0.3		0.4		0.0	0.01		0.2		0.0	

Table 8-1(cont'd). Pathology summary for the simulated weapon experiments in the 3.05 x 2.44 x 2.44- m enclosure.

DATE	ANIMAL	CHARGE WT., g	LW/BW, %	LUNGS		PHARYNX/ LARYNX		TRACHEA		GI TRACT		SOLID AB. ORGANS		ADJ.SEV. INDEX	RIGHT EAR RUPT'E	RIGHT EAR SCORE	LEFT EAR RUPT'E	LEFT EAR SCORE	PROTECTION
10/14/92	316	245	DISEASE	NA		NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
10/14/92	317	245	0.89	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
3/25/93	416	245	1.05	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	30%	4	NONE
3/25/93	417	245	0.95	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
3/26/93	418	245	DISEASE	NA		NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
3/26/93	419	245	0.95	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
3/30/93	420	245	1.03	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	0%	0	BFP
3/30/93	421	245	0.93	NEG	0	NEG	0	SL	6	NEG	0	NEG	0	0.11	0%	0	0%	0	BFP
3/31/93	422	245	0.97	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
3/31/93	423	245	0.85	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
5/27/93	460	245	0.93	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	10%	4	NONE
5/27/93	461	245	DISEASE	NA		NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	1	0%	0	NONE
5/28/93	462	245	0.91	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
5/28/93	463	245	0.88	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
6/2/93	464	245	1.01	NEG	0	NEG	0	SL[k]	5	NEG	0	NEG	0	0.09	0%	0	0%	0	BFP
6/2/93	465	245	1.06	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
6/3/93	466	245	0.77	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
6/3/93	467	245	0.97	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
6/4/93	468	245	0.94	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	5%	4	NONE
6/4/93	469	245	0.81	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	1%	3	NONE
6/9/93	472	245	0.97	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
6/9/93	473	245	0.85	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
6/10/93	474(h)	245	1.01	NEG	0	NEG(e)	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
6/10/93	475	245	0.81	NEG	0	TRACE	3	NEG	0	NEG(b)	0	NEG	0	0.05	0%	0	0%	0	BFP
6/11/93	476	245	0.88	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	2	0%	0	EAR
6/11/93	477	245	0.96	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
6/15/93	478	245	0.92	NEG	0	NEG	0	SL(k)	5	NEG	0	NEG	0	0.09	5%	10	0%	0	NONE
6/15/93	479	245	0.97	NEG	0	NEG	0	SL(k)	5	NEG	0	NEG	0	0.09	1%	3	5%	10	NONE
6/16/93	480	245	1.04	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
6/16/93	481	245	DISEASE	NA	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	0%	0	EART
6/22/93	482	245	0.85	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	2	0%	0	BFP
6/22/93	483	245	0.86	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	BFP
6/23/93	484	245	0.82	NEG	0	TRACE	3	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
6/23/93	485	245	0.84	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
6/24/93	486	245	0.87	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
6/24/93	487	245	0.94	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
6/25/93	488	245	0.86	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
6/25/93	489	245	0.96	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
7/7/93	490	245	0.76	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
7/7/93	491	245	0.83	NEG	0	TRACE	3	NEG	0	NEG	0	NEG	0	0.05	0%	0	0%	0	BFP
MEAN	n =40		0.91		0.0		0.2		0.5		0.0		0.0	0.01		0.8		0.6	
SD			0.08		0.0		0.8		1.6		0.0		0.0	0.03		1.9		1.9	
SE			0.01		0.0		0.1		0.3		0.0		0.0	0.00		0.3		0.3	

Table B-1(cont'd). Pathology summary for the simulated weapon experiments in the 3.05 x 2.44 x 2.44- m enclosure.

DATE	ANIMAL	CHARGE WT., g	LW/BW, %	LUNGS		PHARYNX/ LARYNX		TRACHEA		GI TRACT		SOLID AB. ORGANS		ADJ.SEV. INDEX	RIGHT EAR RUPT'E	RIGHT EAR SCORE	LEFT EAR RUPT'E	LEFT EAR SCORE	PROTEC-TION
				THREE EXPOSURES															
1/19/93	370	302	0.88	TRACE	4	NEG	0	NEG	0	NEG	0	NEG	0	0.06	INF	INF	0%	0	EAR
1/19/93	371	302	0.91	NEG	0	NEG	0	TRACE	3	NEG	0	NEG	0	0.05	0%	0	0%	0	EAR
1/20/93	372	302	0.89	TRACE	4	NEG	0	NEG	0	NEG	0	NEG	0	0.06	0%	0	0%	0	EART
1/20/93	373	302	0.91	SL	5	NEG	0	NEG	0	NEG(o)	0	NEG	0	0.08	0%	0	0%	0	EART
1/27/93	376	302	1.01	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
1/27/93	377	302	DISEASE	NA	0	NEG	0	SL	5	NEG	0	NEG	0	0.09	0%	0	0%	0	BFP
1/28/93	378	302	1.04	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	INF	INF	NONE
1/28/93	379	302	0.88	NEG	0	TRACE	3	SL	5	TRACE	3	NEG	0	0.20	0%	2	0%	0	NONE
1/29/93	380	302	0.88	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	EAR
1/29/93	381	302	1.11	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	EAR
2/2/93	382	302	1.07	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
2/2/93	383	302	DISEASE	NA	0	NEG	0	SL	5	NEG(b)	0	NEG	0	0.09	0%	0	0%	0	EART
2/3/93	384	302	1.08	NEG	0	TRACE	3	SL	5	NEG(b)	0	NEG	0	0.14	0%	0	0%	0	BFP
2/3/93	385	302	1.00	NEG	0	TRACE	4	SL	5	NEG	0	NEG	0	0.16	0%	0	0%	0	BFP
2/4/93	386	302	0.95	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
2/4/93	387	302	1.38	TRACE	4	NEG	0	NEG	0	NEG	0	NEG	0	0.23	5%	4	0%	0	NONE
2/5/93	388	302	1.02	NEG	0	NEG	0	NEG	0	TRACE	3	NEG	0	0.06	0%	0	0%	0	EAR
2/5/93	389	302	0.94	NEG	0	TRACE	3	SL	5	SL	14	NEG	0	0.43	0%	0	0%	0	EAR
2/9/93	390	302	1.05	NEG	0	TRACE	3	SL	5	NEG	0	NEG	0	0.14	0%	0	0%	0	EART
2/9/93	391	302	DISEASE	NA	0	TRACE	3	SL	6	NEG	0	NEG	0	0.16	0%	0	0%	0	EART
MEAN	n = 20		1.00		1.0		1.0		2.2		1.0		0.0	0.10		0.3		0.0	
SD			0.13		1.8		1.5		2.5		3.2		0.0	0.11		1.0		0.0	
SE			0.03		0.4		0.3		0.6		0.7		0.0	0.02		0.2		0.0	
2/11/93	394	245	0.95	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
2/11/93	395	245	0.95	NEG	0	NEG	0	SL	5	NEG	0	NEG	0	0.09	0%	0	0%	0	EAR
2/12/93	396	245	1.14	NEG	0	TRACE	3	SL	5	NEG	0	NEG	0	0.14	0%	0	0%	0	EART
2/12/93	397	245	0.96	NEG	0	TRACE	3	SL	5	NEG	0	NEG	0	0.14	0%	0	0%	0	EART
2/17/93	398	245	0.98	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
2/17/93	399	245	0.79	SL	7	NEG	0	NEG	0	SL	5	NEG	0	0.21	5%	4	0%	0	BFP(L)
2/19/93	400	245	1.00	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
2/19/93	401	245	0.98	NEG	0	NEG	0	SL	6	NEG(b)	0	NEG	0	0.11	1%	4	0%	0	NONE
2/23/93	402	245	1.00	TRACE	3	NEG	0	SL	5	TRACE	4	NEG	0	0.20	0%	0	0%	0	EAR
2/23/93	403	245	DISEASE	NA		NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	EAR
MEAN	n = 10		0.97		1.1		0.6		2.6		0.9		0.0	0.09		0.8		0.0	
SD			0.09		2.4		1.3		2.8		1.9		0.0	0.08		1.7		0.0	
SE			0.03		0.8		0.4		0.9		0.6		0.0	0.03		0.5		0.0	

Table B-1(cont'd). Pathology summary for the simulated weapon experiments in the 3.05 x 2.44 x 2.44- m enclosure.

DATE	ANIMAL	CHARGE WT., g	LW/BW, %	LUNGS		PHARYNX/ LARYNX		TRACHEA		GI TRACT		SOLID AB. ORGANS		ADJ.SEV. INDEX	RIGHT EAR RUPT'E	RIGHT EAR SCORE	LEFT EAR RUPT'E	LEFT EAR SCORE	PROTECTION
4/1/93	424	203	0.91	NEG	0	NEG	0	NEG	0	NEG(p)	0	NEG	0	0.00	0%	0	0%	0	EAR
4/1/93	425	203	DISEASE	NA		NEG	0	SL	5	NEG	0	NEG	0	0.09	0%	0	0%	0	EAR
4/2/93	426	203	0.98	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	30%	4	NONE
4/2/93	427	203	0.99	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	1	1%	3	NONE
4/22/93	430	203	1.03	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
4/22/93	431	203	0.90	NEG	0	NEG	0	SL	5	NEG	0	NEG	0	0.09	0%	0	0%	0	EART
4/27/93	432	203	1.00	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
4/27/93	433	203	DISEASE	NEG		NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
4/28/93	434	203	0.84	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
4/28/93	435	203	0.88	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
4/29/93	436	203	0.87	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	0%	0	NONE
4/29/93	437	203	0.99	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	1%	3	NONE
4/30/93	438	203	0.99	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
4/30/93	439	203	1.09	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
5/4/93	440	203	1.14	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	BFP
5/4/93	441	203	1.13	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
5/11/93	444	203	1.16	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
5/11/93	445	203	0.92	NEG	0	NEG	0	SL(k)	5	NEG	0	NEG	0	0.09	0%	0	0%	0	EAR
5/12/93	446	203	0.97	NEG	0	NEG	0	SL(k)	5	NEG	0	NEG	0	0.09	5%	4	0%	0	NONE
5/12/93	447	203	1.01	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	0%	0	NONE
5/13/93	448	203	0.96	NEG	0	NEG	0	NEG(i)	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
5/13/93	449	203	0.89	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
5/19/93	450	203	DISEASE	NEG		NEG	0	NEG	0	NEG	0	NEG	0	0.00	10%	4	0%	0	BFP(l)
5/19/93	451	203	0.97	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	0%	0	BFP(l)
5/20/93	452	203	0.92	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
5/20/93	453	203	0.93	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
5/21/93	454	203	1.03	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	N/A		N/A		NONE
5/21/93	455	203	0.88	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	1%	3	1%	3	NONE
5/26/93	458	203	0.90	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
5/26/93	459	203	0.93	NEG	0	TRACE	4	NEG	0	NEG	0	NEG	0	0.07	0%	0	0%	0	EART
7/8/93	492	203	0.76	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
7/8/93	493	203	1.03	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
7/9/93	494	203	1.03	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
7/9/93	495	203	0.90	NEG	0	TRACE	3	NEG(i)	0	NEG	0	NEG	0	0.05	0%	0	0%	0	BFP
7/13/93	496	203	0.87	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	1%	3	OPEN
7/13/93	497	203	1.01	NEG	0	NEG	0	NEG(m)	0	NEG	0	NEG	0	0.00	0%	0	0%	0	OPEN
7/14/93	498	203	0.87	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	50%	4	0%	0	EART
7/14/93	499	203	0.98	NEG	0	NEG	0	NEG	0	NEG(r)	0	NEG	0	0.00	0%	0	0%	0	EART
7/15/93	500	203	0.95	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
7/15/93	501	203	0.90	NEG	0	NEG	0	NEG	0	NEG(b)	0	NEG	0	0.00	0%	0	0%	0	BFP
MEAN	n = 40		0.96		0.0		0.2		0.5		0.0		0.0	0.01		0.8		0.4	
SD			0.09		0.0		0.8		1.5		0.0		0.0	0.03		1.4		1.1	
SE			0.01		0.0		0.1		0.2		0.0		0.0	0.00		0.2		0.2	

Table B-1(cont'd). Pathology summary for the simulated weapon experiments in the 3.05 x 2.44 x 2.44- m enclosure.

DATE	ANIMAL	CHARGE WT., g	LW/BW, %	LUNGS		PHARYNX/ LARYNX		TRACHEA		GI TRACT		SOLID AB. ORGANS		ADJ.SEV. INDEX	RIGHT EAR RUPT'E	RIGHT EAR SCORE	LEFT EAR RUPT'E	LEFT EAR SCORE	PROTECTION
						CONTROLS													
9/1/92	282	CONTROL	0.85	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
9/1/92	283	CONTROL	0.92	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	MUFF
9/11/12	288	CONTROL	1.11	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	IP
9/11/92	289	CONTROL	0.96	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
9/15/92	290	CONTROL	0.91	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	FP
9/15/92	291	CONTROL	0.97	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	IP
9/24/92	302	CONTROL	0.99	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
9/24/92	303	CONTROL	DISEASE	NA		NEG(e)	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	20%	4	NONE
10/6/92	310	CONTROL	0.98	NEG	0	TRACE	4	NEG	0	NEG	0	NEG	0	0.07	0%	0	0%	0	EAR
10/6/92	311	CONTROL	1.10	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
10/15/92	318	CONTROL	1.00	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
10/15/92	319	CONTROL	1.01	NEG	0	TRACE	3	NEG	0	NEG	0	NEG	0	0.05	0%	0	0%	0	NONE
10/28/92	328	CONTROL	0.94	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
10/28/92	329	CONTROL	0.82	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
12/2/92	350	CONTROL	0.99	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
12/2/92	351	CONTROL	0.95	NEG	0	NEG	0	NEG(i)	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
1/6/93	362	CONTROL	0.98	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
1/6/93	363	CONTROL	0.91	NEG	0	NEG	0	SL(k)	5	NEG	0	NEG	0	0.09	0%	0	0%	0	EAR
1/21/93	374	CONTROL	0.99	NEG	0	NEG	0	NEG	0	NEG(o)	0	NEG	0	0.00	0%	0	0%	0	BFP
1/21/93	375	CONTROL	0.96	NEG	0	NEG	0	SL(k)	6	NEG	0	NEG	0	0.11	0%	0	0%	0	BFP
2/10/93	392	CONTROL	1.02	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
2/10/93	393	CONTROL	0.96	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
2/24/93	404	CONTROL	0.96	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
2/24/93	405	CONTROL	0.95	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
3/11/93	414	CONTROL	1.03	NEG	0	NEG	0	NEG	0	NEG(o)	0	NEG	0	0.00	0%	0	0%	0	EART
3/11/93	415	CONTROL	0.79	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
4/6/93	428	CONTROL	1.12	NEG	0	SL(q)	5	NEG	0	NEG	0	NEG	0	0.08	0%	0	0%	0	NONE
4/6/93	429	CONTROL	DISEASE	NA		NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	NONE
5/5/93	442	CONTROL	1.05	NEG	0	NEG	0	NEG	0	TRACE	4	NEG	0	0.08	0%	0	0%	0	EAR
5/5/93	443	CONTROL	0.91	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EAR
5/25/93	456	CONTROL	0.91	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
5/25/93	457	CONTROL	0.96	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	BFP
6/8/93	470	CONTROL	1.12	NEG	0	NEG	0	NEG	0	NEG	0	NEG	0	0.00	0%	0	0%	0	EART
6/8/93	471	CONTROL	0.98	NEG	0	NEG	0	SL(k)	5	NEG	0	NEG	0	0.09	0%	0	0%	0	EART
MEAN	n = 34		0.97		0.0		0.4		0.5		0.1		0.0	0.02		0.0		0.1	
SD			0.08		0.0		1.2		1.5		0.7		0.0	0.03		0.0		0.7	
SE			0.01		0.0		0.2		0.3		0.1		0.0	0.01		0.0		0.1	

(a)There was a grade 4 linear contusion on the posterior portion of the ventral sac of the rumen that was not blast induced.

(b)Scattered petchiation on adipose of greater omentum, which may be precursor to abomasal contusion.

(c)Plugs had slipped out of canals but were still in auricles.

(d)Not typical ecchymotic lesion. It is diffuse, not well defined .

Table 8-1(cont'd). Pathology summary for the simulated weapon experiments in the 3.05 x 2.44 x 2.44- m enclosure.

DATE	ANIMAL	CHARGE WT., g	LW/BW, %	LUNGS	PHARYNX/ LARYNX	TRACHEA	GI TRACT	SOLID AB. ORGANS	ADJ.SEV. INDEX	RIGHT EAR RUPT'E	RIGHT EAR SCORE	LEFT EAR RUPT'E	LEFT EAR SCORE	PROTEC-TION
(e)There was a grade 5 lesion on the pharynx / larynx consistiing of scattered purplish petechiation thought to be related to the diseased state of the lungs or agonal changes.														
(f)Right plug had slipped out of canal but was still in auricle.														
(g)Tip of ossicle was fractured but the drum appeared to be intact.														
(h)Agonal hemorrhage found on the heart . Sheep from new herd.														
(i)Ecchymotic area in anterior portion,possibly caused by sheep running into the gate or tracheitis exacerbated by the blast in case of test animals or manipulation during exsanguination.														
(j)Four petechia only scattered over three different areas.														
(k)Probably tracheitis consisting of a mucosal erythemia with slight superimposed ecchymosis in mid to posterior portion.														
(l)Right plug had slipped out of canal . Found on floor .														
(m) Small linear streaks of mucosal ecchymosis just below clamp mark probably iatrogenic in origin.														
(n)Light pleural petechiation agonal in origin. Subject exhibited discomfort and labored breathing before and during test period														
(o)Haemonchus contortus induced mucosal petechiation in abomasum.														
(p)Scattered petechia adipose greater omentum plus hyperemia and edema of three abomasum folds.														
(q)Petechia only, but in two differnt locations.														
(r)This lesion was probably a pre-existing condition exacerbated by the blast judging from the extensive edema of rugal folds and lack of injury to other organs.														

APPENDIX C

WALL GAUGE NUMBER 10 PRESSURE-TIME SUMMARY

Table C-1. Wall gauge number 10 pressure-time summary for the Carl-Gustav blast simulation tests in the 3.05 x 2.44 x 2.44- m enclosure.

Date	Animal	Charge Wt., g	Shot No.	Test No.	Pmax, kPa	Psm, kPa	Imax, kPa*msec
			12 EXPOSURES (MEANS)				
8/31/92	281	1361	1,6,12	1	695.5	145.0	798.0
9/3/92	284	1361	1,6,12	3	767.9	94.3	790.5
9/3/92	285	1361					
9/10/92	286	1361	1,6,12	4	228.4	91.1	821.5
9/10/92	287	1361					
Mean			n = 3		563.9	110.1	803.3
SD					292.8	30.2	16.2
SE					169.1	17.5	9.3
9/16/92	292	816	1,6,12	7	131.3	61.8	397.8
9/16/92	293	816					
9/17/92	294	816	1,6,12	8	129.5	64.2	380.8
9/17/92	295	816					
Mean			n = 2		130.4	63.0	389.3
SD					1.3	1.7	12.0
SE					0.9	1.2	8.5
9/18/92	296	533	1,6,12	9	86.6	42.2	224.9
9/18/92	297	533					
9/21/92	298	533	1,6,12	10	78.5	41.9	258.5
9/21/92	299	533					
Mean			n= 2		82.6	42.1	241.7
SD					5.7	0.2	23.8
SE					4.0	0.2	16.8
9/23/92	300	359	1,6,12	11	52.3	28.7	145.9
9/23/92	301	359					
11/3/92	330	359	1,6,12	26	57.1	31.4	169.7
11/3/92	331	359					
Mean			n = 2		54.7	30.1	157.8
SD					3.4	1.9	16.8
SE					2.4	1.4	11.9
9/25/92	304	245	1,6,12	13	36.6	20.4	102.3
9/25/92	305	245					
10/16/92	320	245	1,6,12	21	42.4	22.7	102.0
10/16/92	321	245					
Mean			n = 2		39.5	21.6	102.2
SD					4.1	1.6	0.2
SE					2.9	1.2	0.1
			SINGLE EXPOSURES				
9/29/92	306	1361	1	14	141.1	88.3	774.8
9/29/92	307	1361					
Mean			n = 1		141.1	88.3	774.8
SD							
SE							
9/30/92	308	816	1	15	117.8	67.8	442.1
9/30/92	309	816					
10/27/92	326	816	1	24	130.4	63.6	376.9
10/27/92	327	816					

Table C-1(cont'd). Wall gauge number 10 pressure-time summary for the Carl-Gustav blast simulation tests in the 3.05 x 2.44 x 2.44- m enclosure.

Date	Animal	Charge Wt., g	Shot No.	Test No.	Pmax, kPa	Psm, kPa	Imax, kPa*msec
11/10/92	332	816	1	27	130.0	66.4	365.0
11/10/92	333	816					
11/11/92	334	816	1	28	147.2	75.6	677.8
11/11/92	335	816					
Mean			n = 4		131.4	68.4	465.5
SD					12.1	5.1	145.6
SE					6.0	2.6	72.8
11/12/92	336	656	1	29	175.2	55.6	327.0
11/12/92	337	656					
11/17/92	338	656	1	30	163.7	60.8	308.1
11/17/92	339	656					
Mean			n = 2		169.5	58.2	317.6
SD					8.1	3.7	13.4
SE					5.8	2.6	9.5
10/8/92	312	533	1	17	86.2	43.1	257.0
10/8/92	313	533					
10/23/92	324	533	1	23	114.0	49.0	254.9
10/23/92	325	533					
11/19/92	340(h)	533	1	31	163.0	48.8	279.1
11/19/92	341	533					
11/20/92	342	533	1	32	121.0	44.5	252.4
11/20/92	343	533					
1/0/00	344	533	1	33	121.7	46.1	267.7
1/0/00	345	533					
11/25/92	346	533	1	34	96.9	43.4	270.3
11/25/92	347	533					
12/1/92	348	533	1	35	137.8	45.7	251.0
12/1/92	349	533					
12/3/92	352	533	1	37	113.8	44.9	231.7
12/3/92	353	533					
12/7/92	354	533	1	38	86.7	45.9	257.9
12/7/92	355	533					
12/16/92	356	533	1	39	112.2	46.0	243.8
1/0/00	357	533					
12/18/92	358	533	1	40	143.7	46.5	240.4
12/18/92	359	533					
1/5/93	360	533	1	41	91.5	41.7	233.0
1/5/93	361	533					
1/7/93	364	533	1	43	82.5	44.9	225.2
1/7/93	365	533					
1/8/93	366	533	1	44	102.0	45.8	241.7
1/8/93	367	533					
1/12/93	368	533	1	45	101.6	43.8	274.4
1/0/00	369	533					
Mean			n = 15		111.6	45.3	252.0
SD					23.1	2.0	16.2
SE					6.0	0.5	4.2
10/9/92	314	359	1	18	64.7	32.0	173.7
10/9/92	315	359					
10/21/92	322	359	1	22	76.1	36.7	153.4
10/21/92	323	359					

Table C-1(cont'd). Wall gauge number 10 pressure-time summary for the Carl-Gustav blast simulation tests in the 3.05 x 2.44 x 2.44- m enclosure.

Date	Animal	Charge Wt., g	Shot No.	Test No.	Pmax, kPa	Psm, kPa	Imax, kPa*msec
3/2/93	406	359	1	64	53.1	32.9	130.7
3/2/93	407	359					
3/3/93	408	359	1	65	53.3	30.7	159.4
3/3/93	409	359					
3/4/93	410	359	1	66	55.9	31.9	139.8
3/4/93	411	359					
3/10/93	412	359	1	67	60.4	32.8	147.3
3/10/93	413	359					
Mean			n = 6		60.6	32.8	150.7
SD					8.8	2.1	15.1
SE					3.6	0.8	6.2
10/14/92	316	245	1	19	41.5	21.0	97.2
10/14/92	317	245					
3/25/93	416	245	1	69	35.6	21.1	82.3
3/25/93	417	245					
3/26/93	418	245	1	70	42.7	24.1	91.9
3/26/93	419	245					
3/30/93	420	245	1	71	38.7	22.9	98.1
3/30/93	421	245					
3/31/93	422	245	1	72	46.0	23.7	99.3
3/31/93	423	245					
5/27/93	460	245	1	91	43.7	22.1	84.0
	461	245					
5/28/93	462	245	1	92	38.0	20.0	84.1
	463	245					
6/2/93	464	245	1	93	45.9	23.9	92.1
	465	245					
6/3/93	466	245	1	94	37.0	20.7	88.7
	467	245					
6/4/93	468	245	1	95	39.8	23.1	97.6
	469	245					
6/9/93	472	245	1	97	43.8	21.3	82.8
	473	245					
6/10/93	474	245	1	98	35.8	21.1	84.6
	475	245					
6/11/93	476	245	1	99	36.4	21.0	84.4
	477	245					
6/15/93	478	245	1	100	43.2	22.8	92.8
	479	245					
6/16/93	480	245	1	101	41.9	22.4	88.4
	481	245					
6/22/93	482	245	1	102	37.1	21.2	79.4
	483	245					
6/23/93	484	245	1	103	41.3	20.2	82.5
	485	245					
6/24/93	486	245	1	104	38.6	22.5	87.7
	487	245					
6/25/93	488	245	1	105	40.5	23.3	89.4
	489	245					
7/7/93	490	245	1	106	40.4	21.5	83.2
	491	245					
Mean			n = 20		40.4	22.0	88.5
SD					3.2	1.2	6.1
SE					0.7	0.3	1.4

Table C-1(cont'd). Wall gauge number 10 pressure-time summary for the Carl-Gustav blast simulation tests in the 3.05 x 2.44 x 2.44- m enclosure.

Date	Animal	Charge Wt., g	Shot No.	Test No.	Pmax, kPa	Psm, kPa	Imax, kPa*msec
			THREE EXPOSURES (MEANS)				
1/19/93	370	302	1thru3	46	52.7	26.8	116.6
1/19/93	371	302					
1/20/93	372	302	1thru3	47	48.8	27.6	124.2
1/20/93	373	302					
1/27/93	376	302	1thru3	49	44.8	27.1	118.5
1/27/93	377	302					
1/28/93	378	302	1thru3	50	44.3	26.1	111.0
1/28/93	379	302					
1/29/93	380	302	1thru3	51	57.3	31.8	141.1
1/29/93	381	302					
2/2/93	382	302	1thru3	52	42.1	25.3	121.0
2/2/93	383	302					
2/3/93	384	302	1thru3	53	45.0	26.3	116.6
2/3/93	385	302					
2/4/93	386	302	1thru3	54	45.6	27.7	119.3
2/4/93	387	302					
2/5/93	388	302	1thru3	55	52.1	27.6	121.6
2/5/93	389	302					
2/9/93	390	302	1thru3	56	56.4	27.8	117.6
2/9/93	391	302					
Mean			n = 10		48.9	27.4	120.7
SD					5.4	1.7	8.0
SE					1.7	0.6	2.5
2/11/93	394	245	1thru3	58	47.9	21.8	96.8
2/11/93	395	245					
2/12/93	396	245	1thru3	59	41.2	21.3	86.1
2/12/93	397	245					
2/17/93	398	245	1thru3	60	38.8	21.5	91.3
2/17/93	399	245					
2/19/93	400	245	1thru3	61	43.8	21.4	88.8
2/19/93	401	245					
2/23/93	402	245	1thru3	62	43.9	21.3	89.5
2/23/93	403	245					
Mean			n = 5		43.1	21.5	90.5
SD					3.4	0.2	4.0
SE					1.5	0.1	1.8
4/1/93	424	203	1thru3	73	41.3	18.2	69.8
	425	203					
4/1/93	426	203	1thru3	74	41.3	18.1	70.7
	427	203					
4/22/93	430	203	1thru3	76	41.9	17.9	70.8
	431	203					
4/27/93	432	203	1thru3	77	35.9	16.6	66.7
	433	203					
4/28/93	434	203	1thru3	78	37.9	16.7	66.1
	435	203					
4/29/93	436	203	1thru3	79	44.3	17.9	69.9
	437	203					
4/30/93	438	203	1thru3	80	38.1	18.2	69.4
	439	203					
5/4/93	440	203	1thru3	81	38.6	17.5	69.2
	441	203					
5/11/93	444	203	1thru3	83	41.5	18.0	72.8

Table C-1(cont'd). Wall gauge number 10 pressure-time summary for the Carl-Gustav blast simulation tests in the 3.05 x 2.44 x 2.44- m enclosure.

Date	Animal	Charge Wt., g	Shot No.	Test No.	Pmax, kPa	Psm, kPa	Imax, kPa*msec
	445	203					
5/12/93	446	203	1thru3	84	36.7	16.0	72.0
	447	203					
5/13/93	448	203	1thru3	85	41.0	17.5	67.5
	449	203					
5/19/93	450	203	1thru3	86	35.7	17.9	72.0
	451	203					
5/20/93	452	203	1thru3	87	37.6	17.9	79.1
	453	203					
5/21/93	454	203	1thru3	88	36.5	17.3	66.2
	455	203					
5/26/93	458	203	1thru3	90	34.1	17.2	65.0
	459	203					
7/8/93	492	203	1thru3	107	37.3	17.4	66.0
	493	203					
7/9/93	494	203	1thru 3	108	33.4	17.2	65.2
	495	203					
7/13/93	496	203	1 thru 3	109	36.2	17.7	71.4
	497	203					
7/14/93	498	203	1 thru 3	110	37.1	16.9	68.2
	499	203					
7/15/93	500	203	1 thru 3	111	36.7	17.6	67.4
	501	203					
Mean			n = 20		38.2	17.6	69.3
SD					2.9	0.5	3.3
SE					0.6	0.1	0.7

APPENDIX D

INDIVIDUAL SEVERITY OF INJURY INDICES

Figure D-1. Individual severity of injury indices as a function of instrumentation cylinder smoothed peak pressure (Psm) for 12 exposures to a simulated Carl-Gustav blast wave in the 3.05 x 2.44 x 2.44- m enclosure.

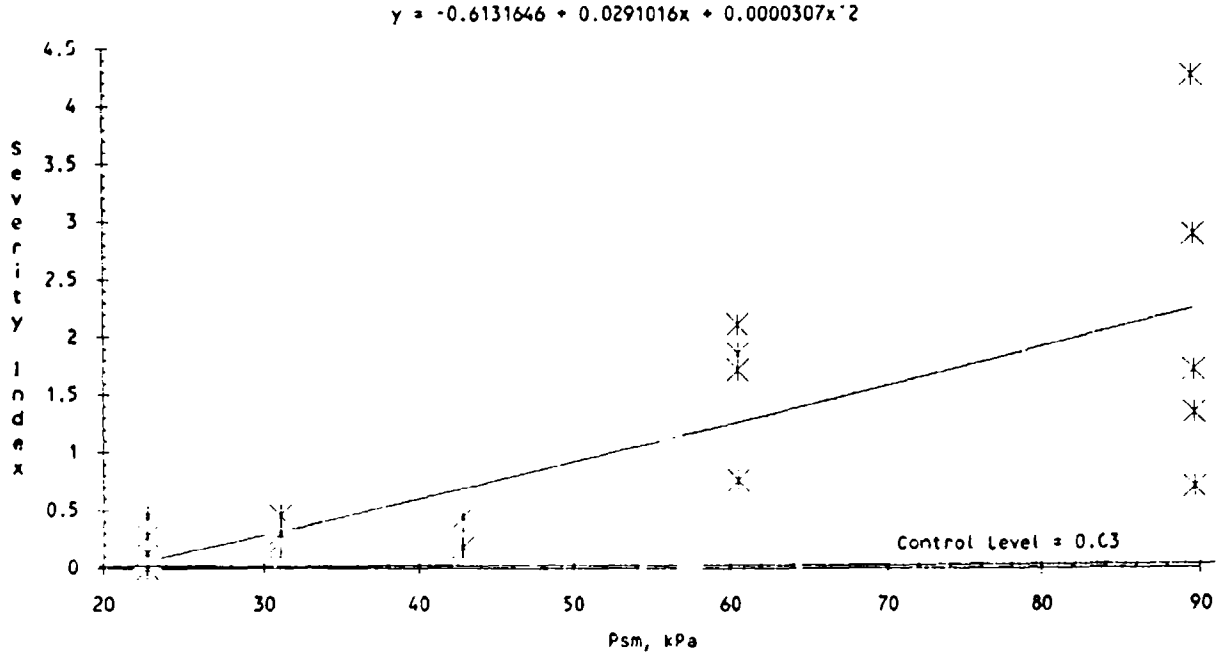


Figure D-2. Individual severity of injury indices as a function of instrumentation cylinder smoothed peak pressures (Psm) for a single exposure toa a simulated Carl-Gustav blast wave in the 3.05 x 2.44 x 2.44- m enclosure.

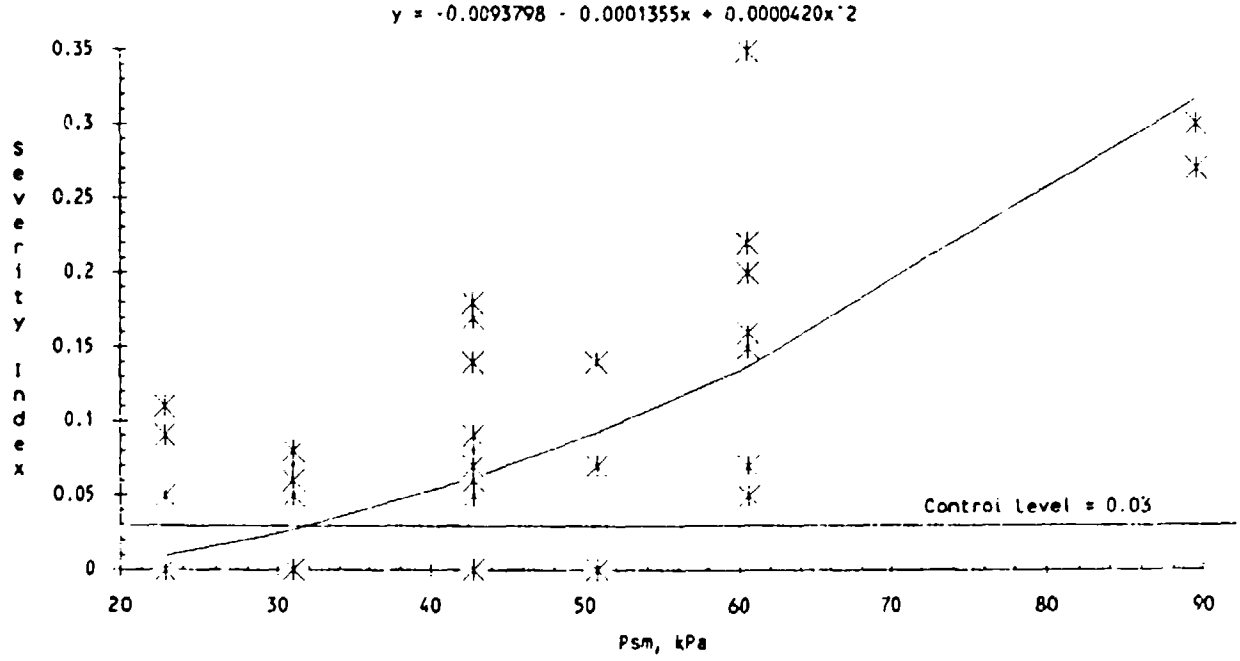


Figure D-3. Individual severity of injury indices as a function of instrumentation cylinder smoothed peak pressure (Psm) for three exposures to a simulated Carl-Gustav blast wave in the 3.05 x 2.44 x 2.44- m enclosure.

$y = -1.8975128 + 0.1592186x - 0.0031619x^2$